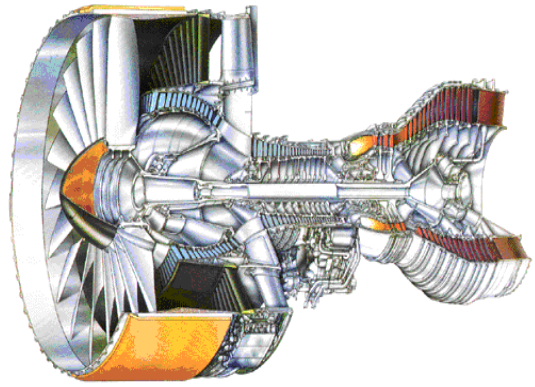
NACT 272

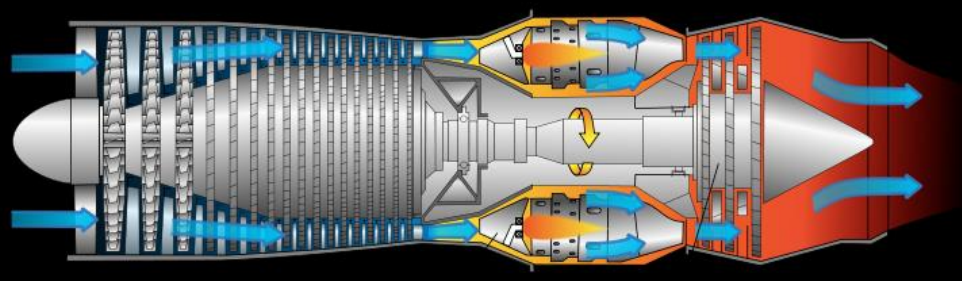


Stationary Gas Turbines

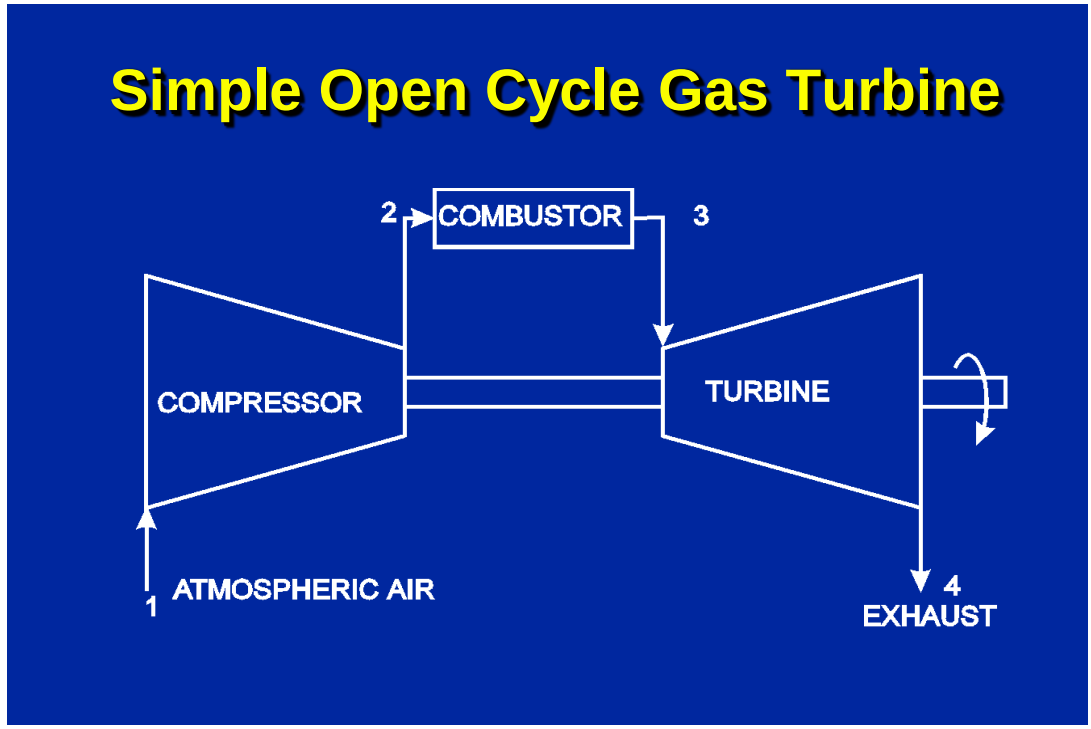
Course Overview

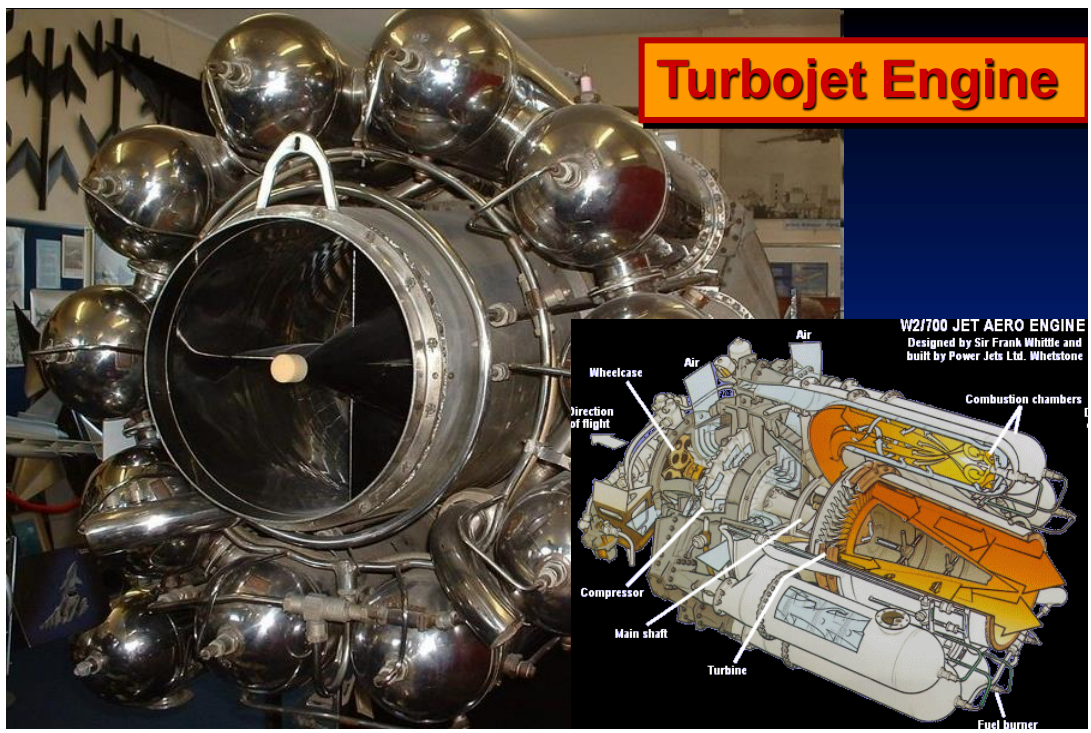
- Gas turbine theory and operation
- Gas turbine uses
- Air pollution control devices
- Gas turbine regulations
- Typical permit conditions
- Inspection procedures
- Continuous emission monitoring
- Source testing requirements

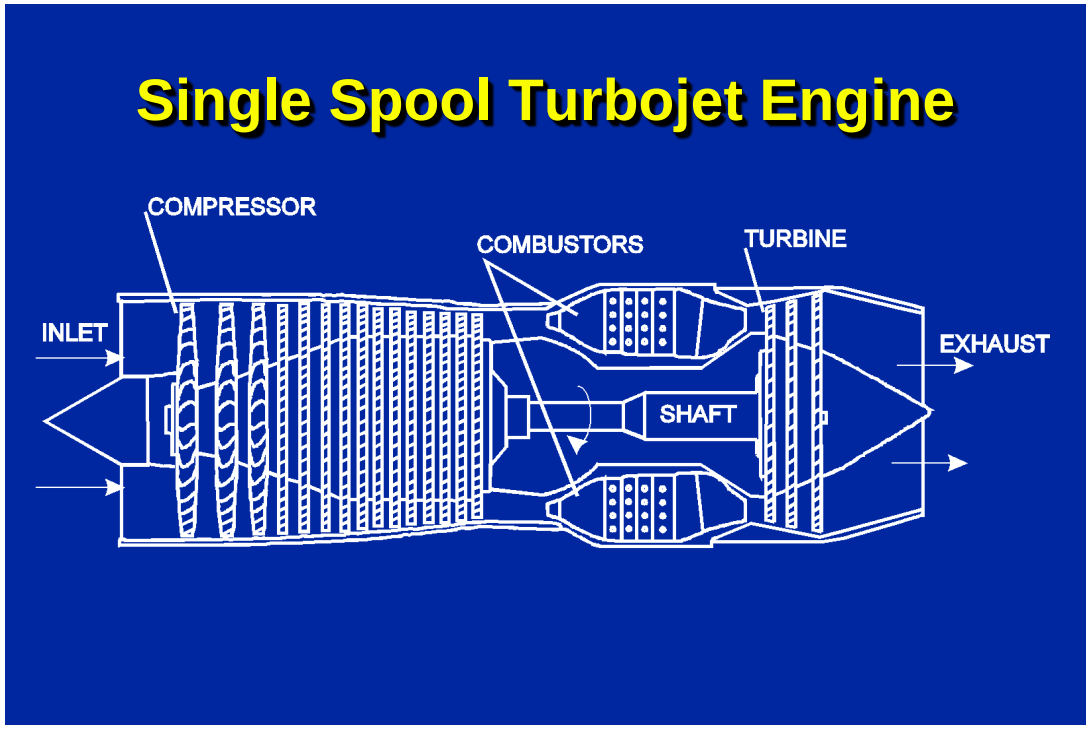
What is a Gas Turbine

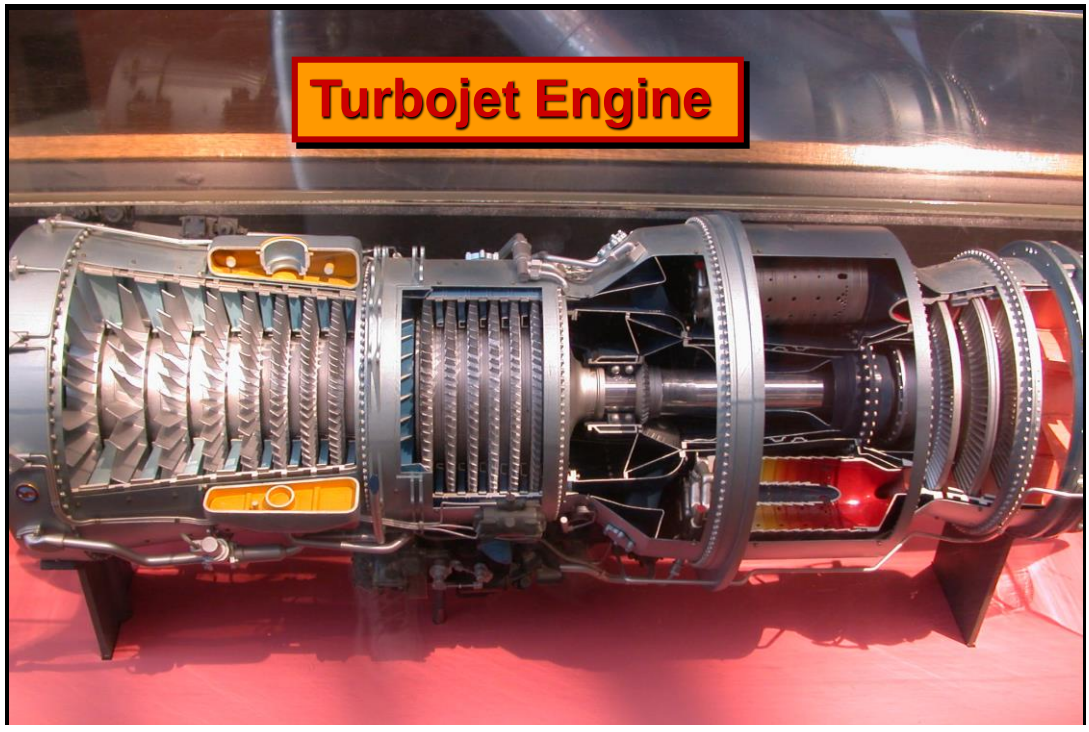


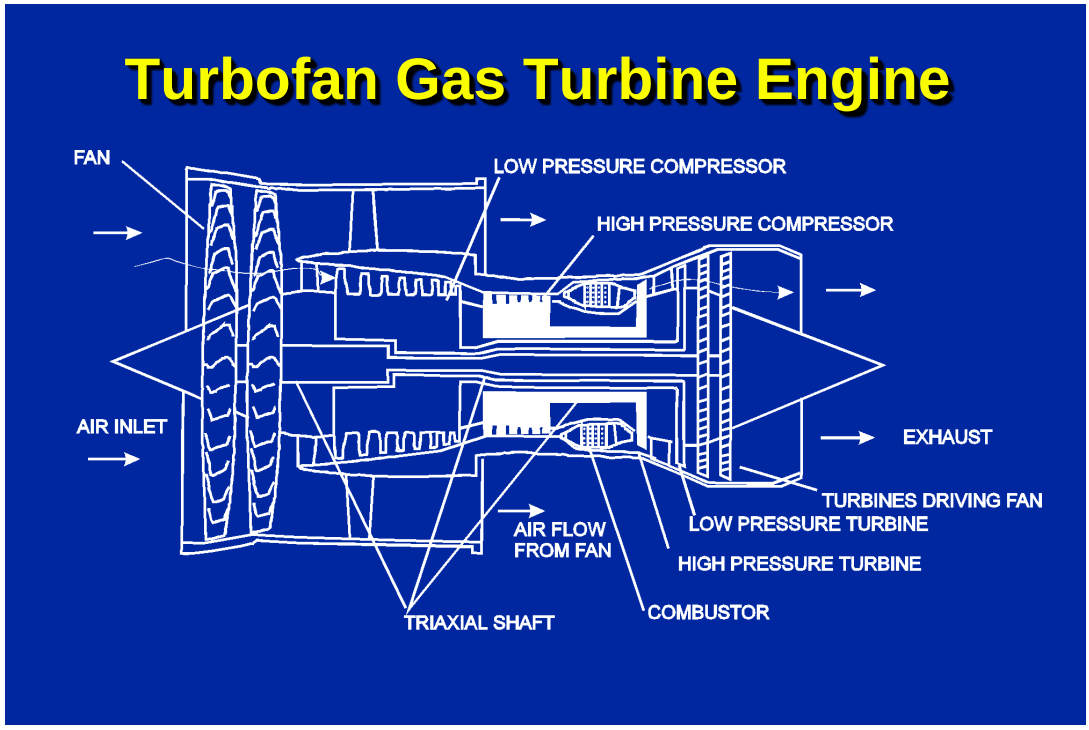
How does a Turbine Work?

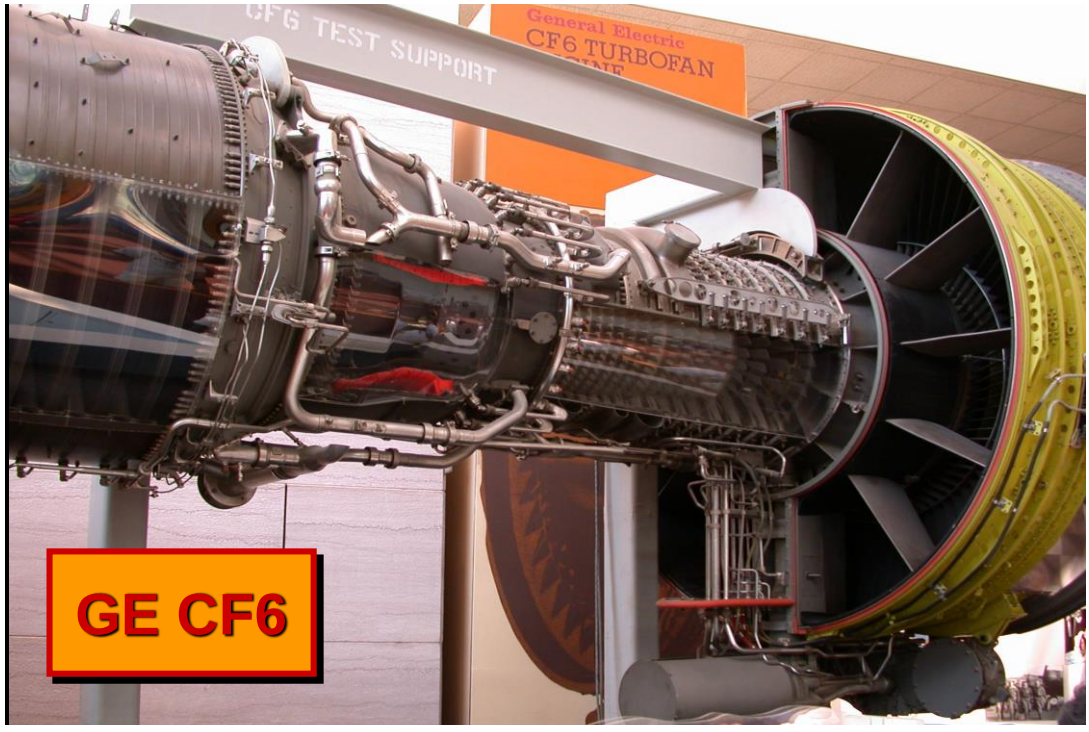

Simple Open Cycle Gas Turbine
2
COMBUSTOR
3
COMPRESSOR
TURBINE
1
ATMOSPHERIC AIR
4
EXHAUST


Turbojet Engine
W2/700 JET AERO ENGINE
Designed by Sir Frank Whittle and built by Power Jets Ltd. Whetstone
Air
Air
Wheelcase
Direction of flight
Combustion chambers
Compressor
Main shaft
Turbine
Fuel burner

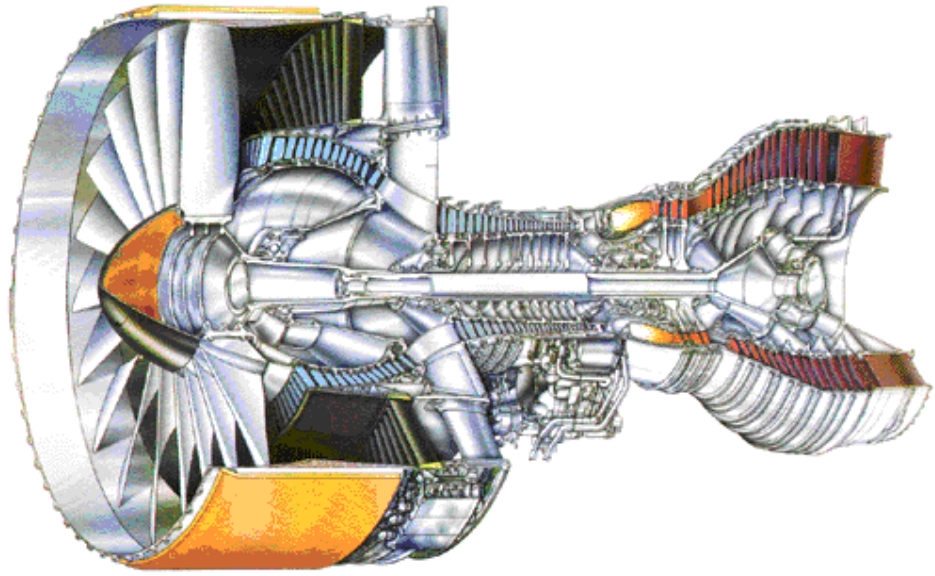

Single Spool Turbojet Engine
COMPRESSOR
COMBUSTORS
TURBINE
INLET
EXHAUST
SHAFT


Turbojet Engine


Turbofan Gas Turbine Engine
FAN
LOW PRESSURE COMPRESSOR
HIGH PRESSURE COMPRESSOR
AIR INLET
EXHAUST
TURBINES DRIVING FAN
LOW PRESSURE TURBINE
AIR FLOW
FROM FAN
HIGH PRESSURE TURBINE
COMBUSTOR
TRIAXIAL SHAFT


CF6 TEST SUPPORT
General Electric
CF6 TURBOFAN
GE CF6

PW4000 112-INCH FAN ENGINE



Jet Aircraft

Stationary Sources

Gas Turbine Uses

Marine Power

Uses of Gas Turbines

- Aircraft - Turbojet, turbofan & turboprop
- Ships
- Electrical Generation -- Base load, peaking, cogeneration and backup
- Natural gas compression and transport
- Water pumping

Advantages

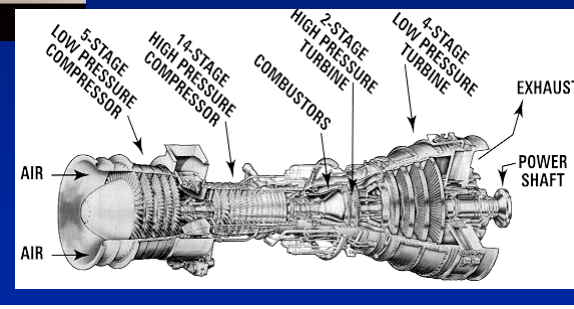
- Relatively small size (power to size ratio)
- Light weight for output (power to weight ratio)
- Requires modest foundation
- Requires no cooling water
- Rapid startup and loading
- Good thermal efficiency
- Low maintenance
- Runs unattended
- Long life

Disadvantages

- Expensive
- Require clean fuel
- Require clean water
- Natural Gas supply
- Transmission Grid
- Use more fuel than IC Engines
- Not efficient at part load

400MW (MEGAWATT) GAS TURBINE

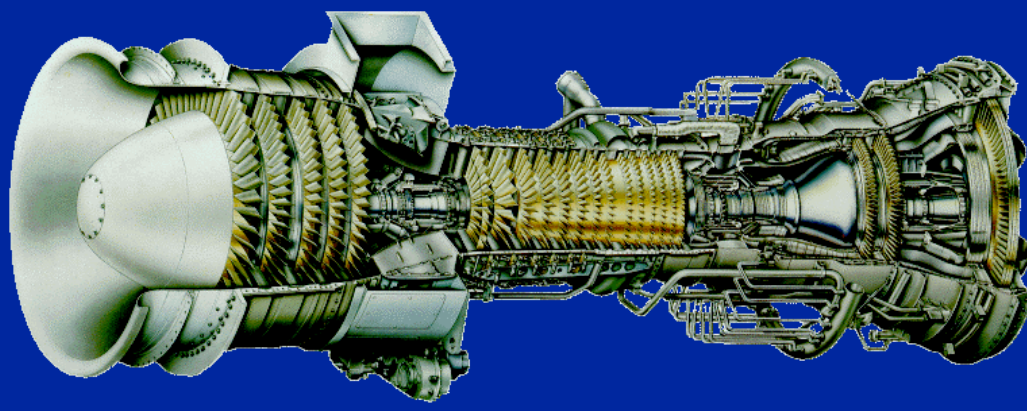
Marine Engines



Aeroderivative Turbines

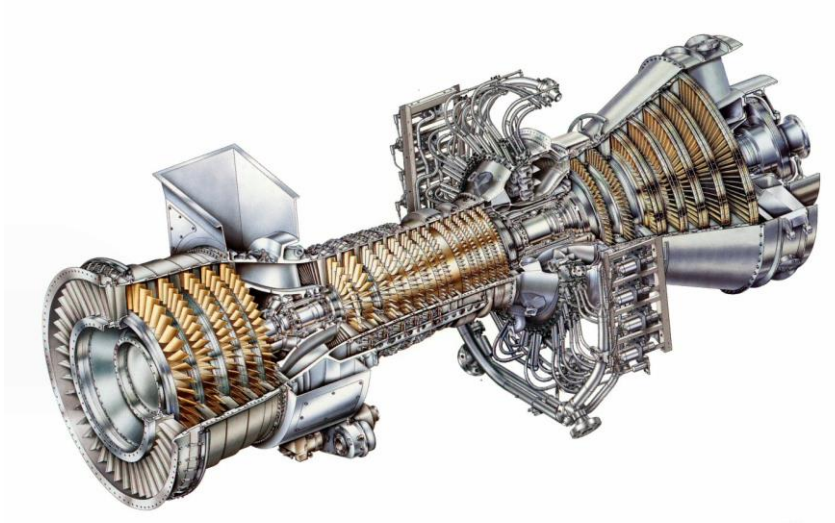
- Based on established product
- High simple cycle efficiency
- High power to weight ratio
- Direct generator drive capability
- Ease and speed of maintenance
- Parts availability

GE LM5000 Gas Turbine

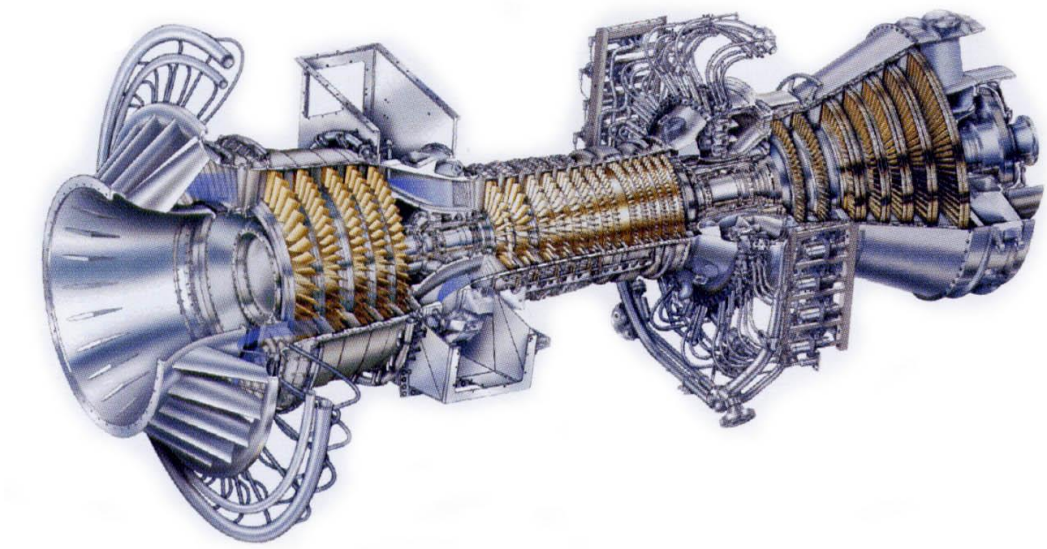


Graphic Courtesy of General Electric

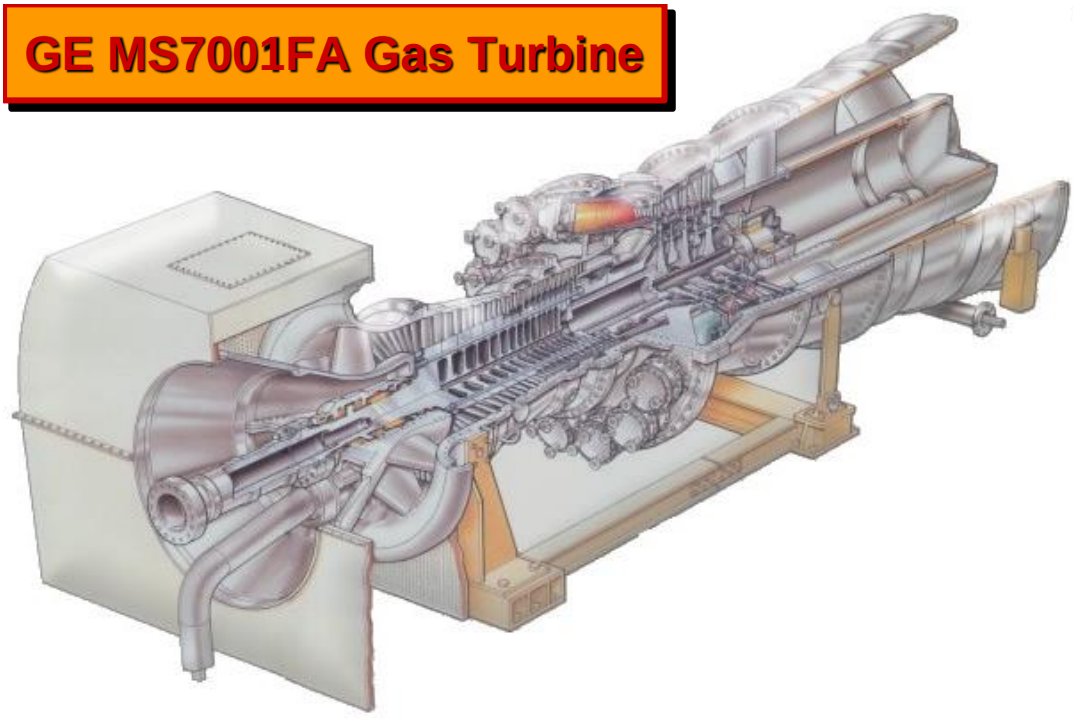
GE LM6000 Gas Turbine



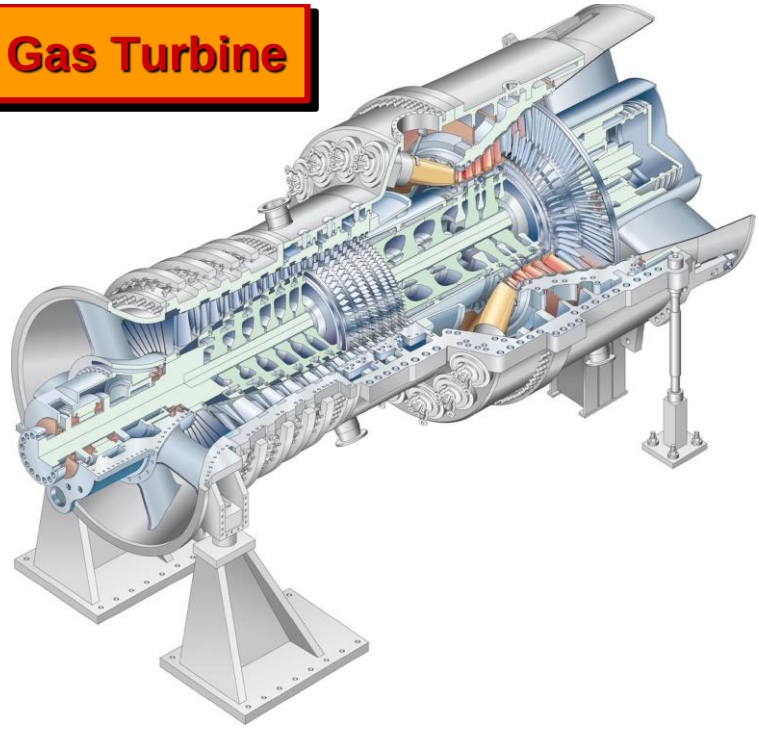
GE LM6000 with Sprint

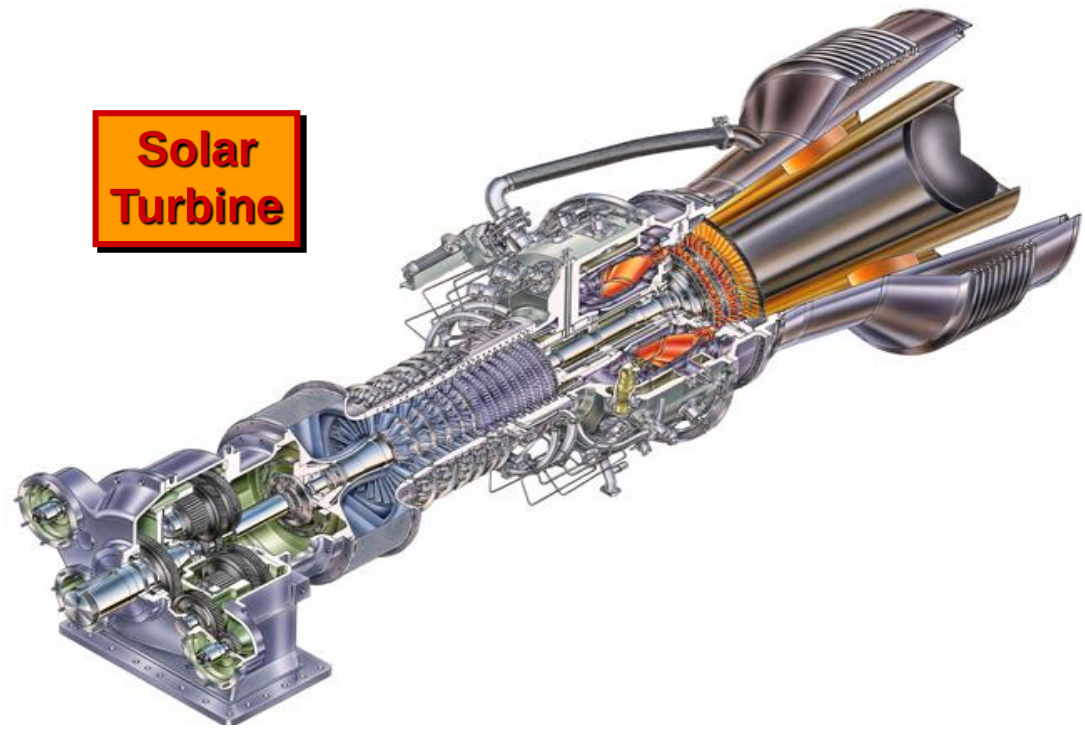


GE MS7001FA Gas Turbine



Siemens Gas Turbine




Solar
Turbine

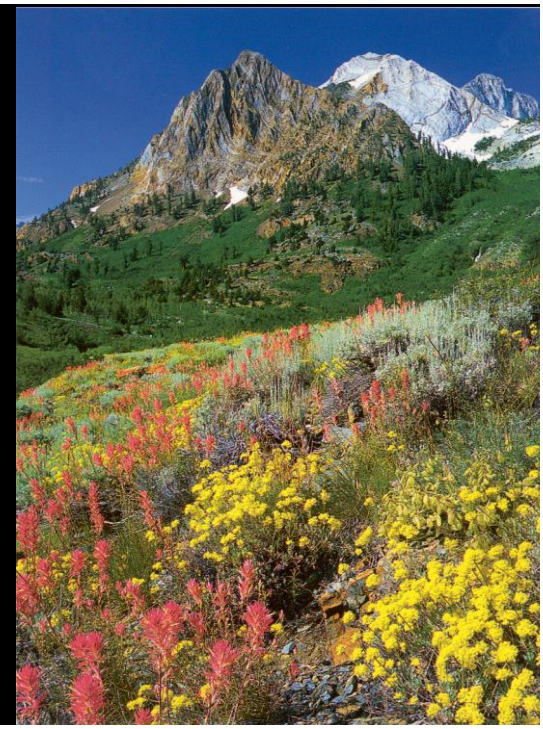

Aeroderivative
Turbine

Aeroderivative Turbine

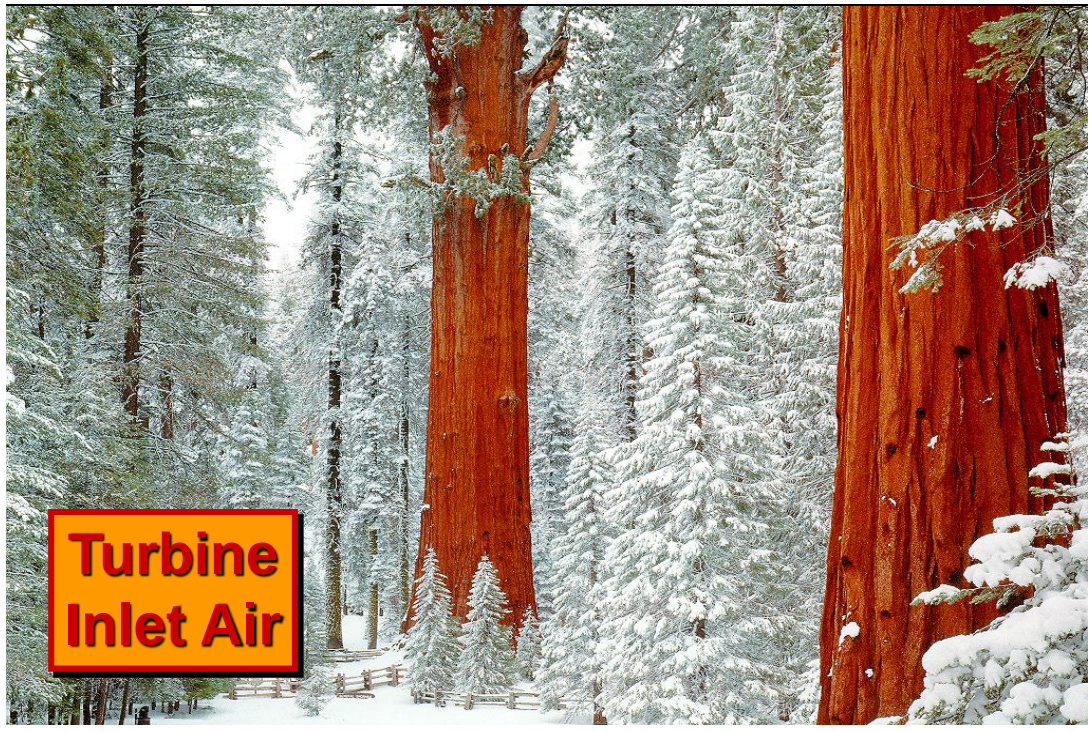
LM 6000 : 50 MW

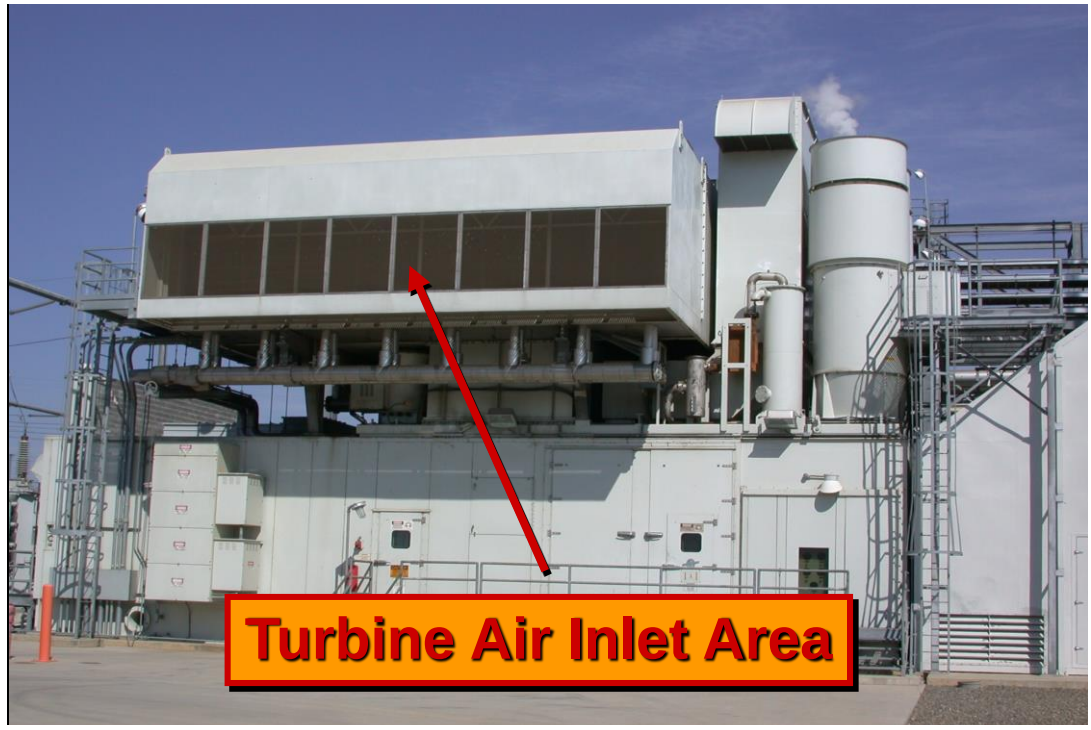
Important Terms

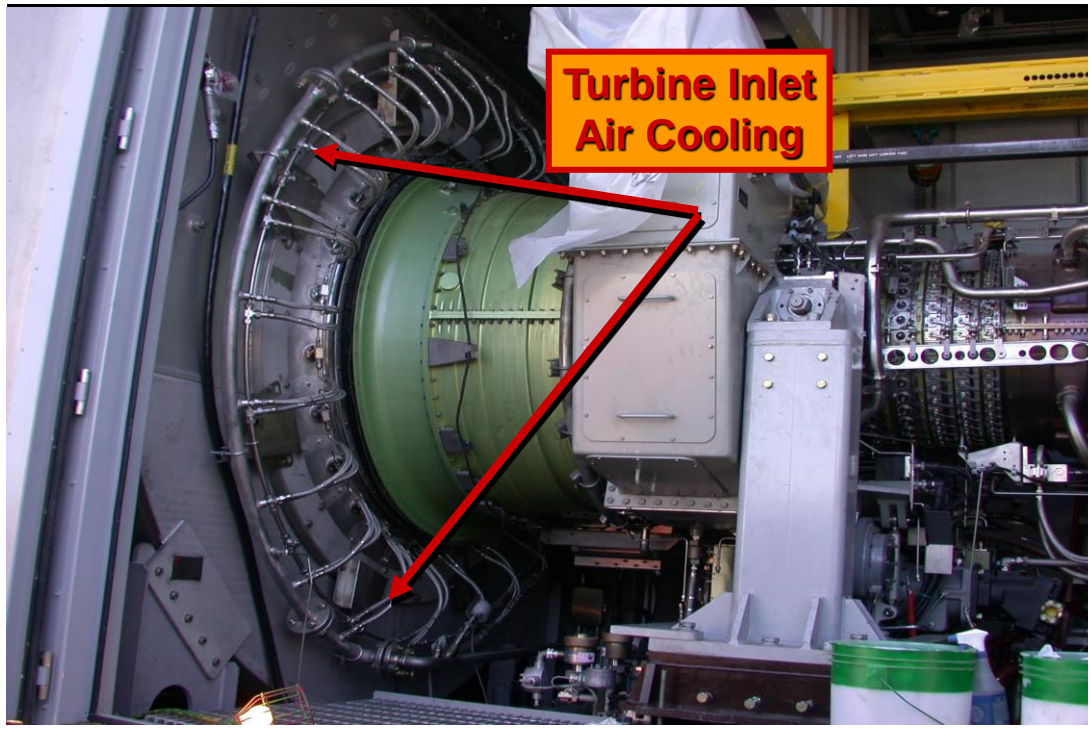
- Power
- Horsepower
- Shaft horsepower
- Megawatt
- Thrust
- Thermal efficiency

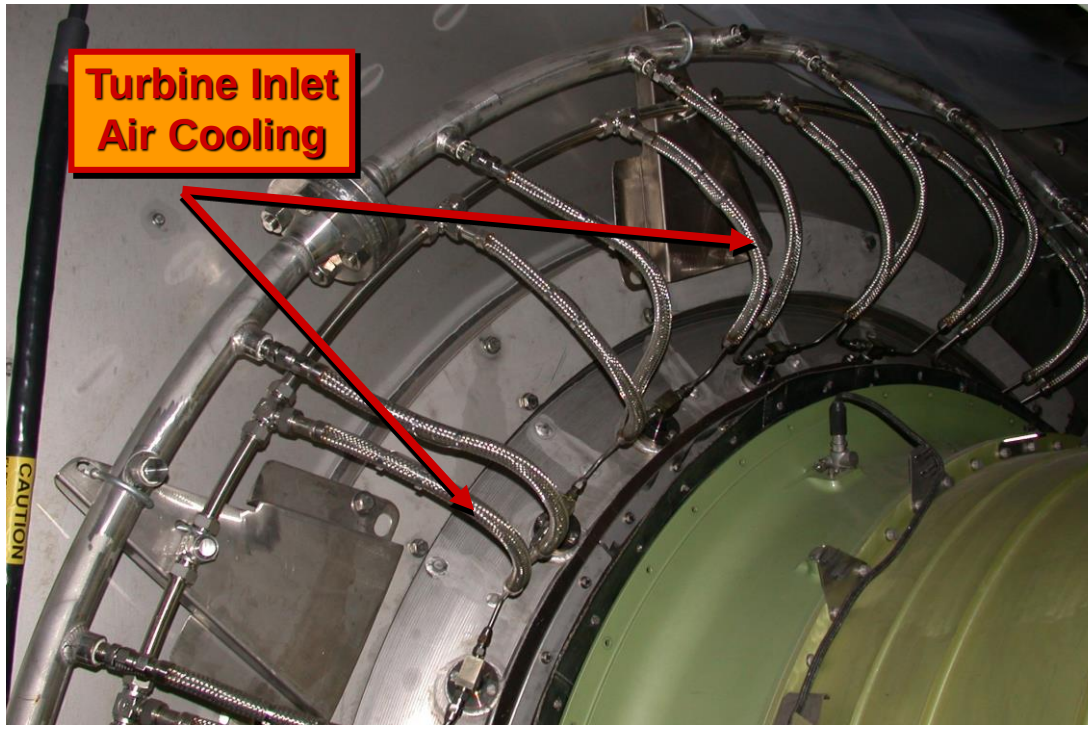


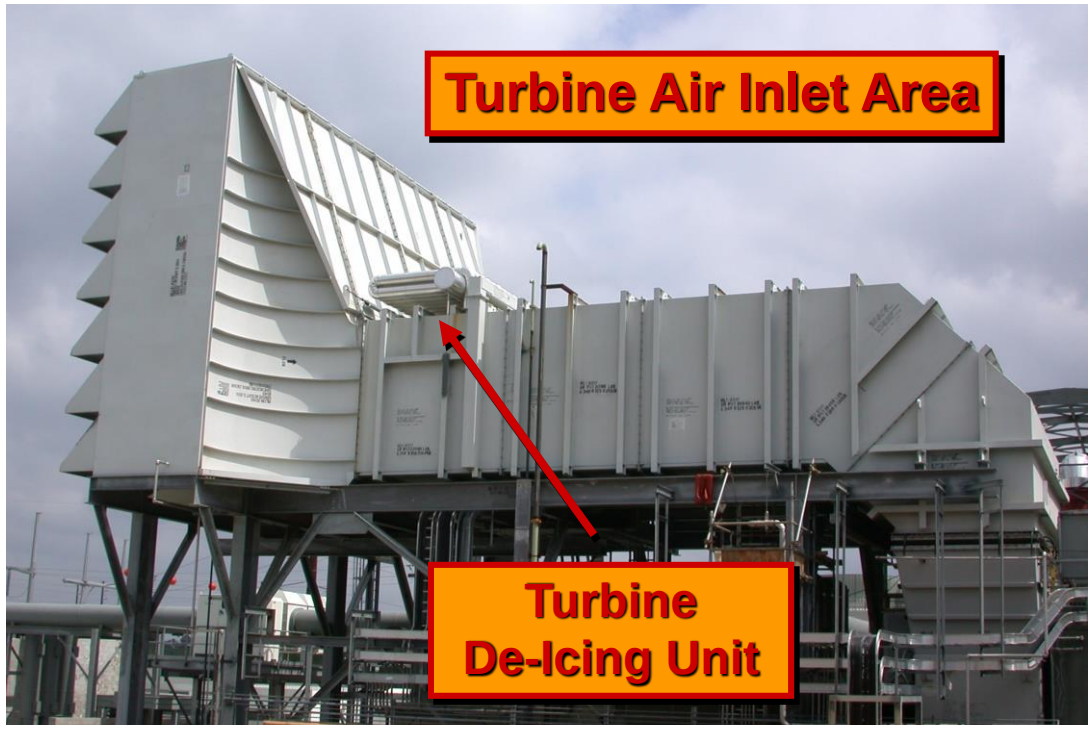

Gas Turbine
Power Plant


Turbine
Inlet Air


Turbine Air Inlet Area


Turbine Inlet
Air Cooling

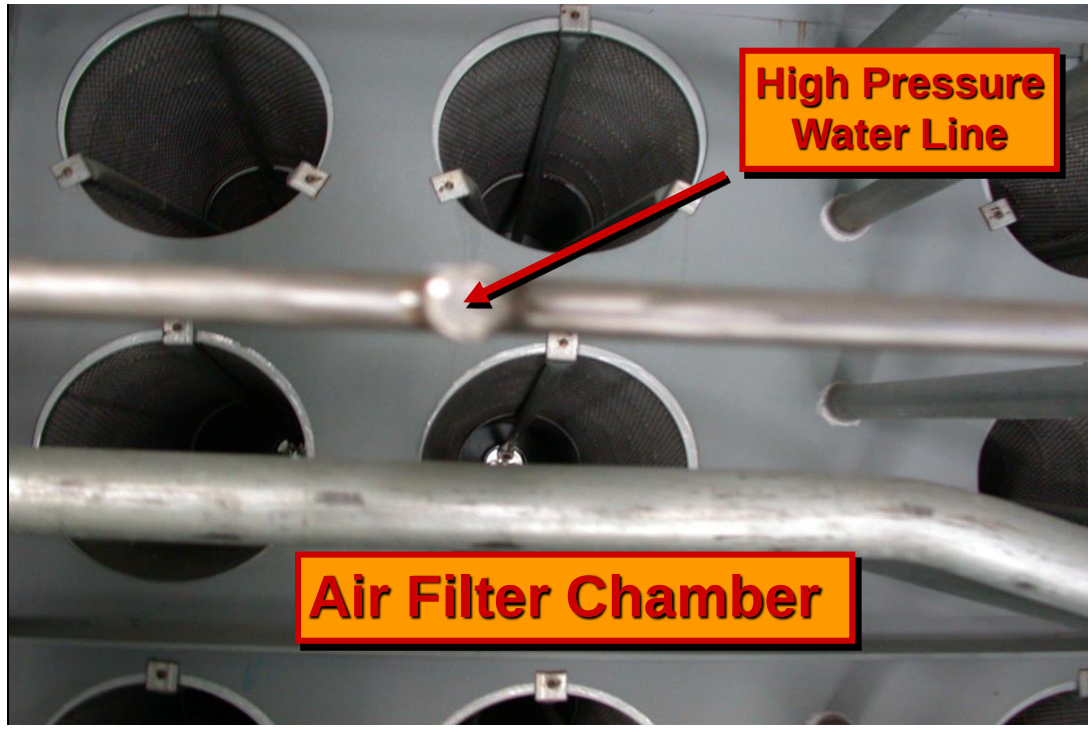

Turbine Inlet
Air Cooling
CAUTION


Turbine Air Inlet Area
Turbine
De-Icing Unit

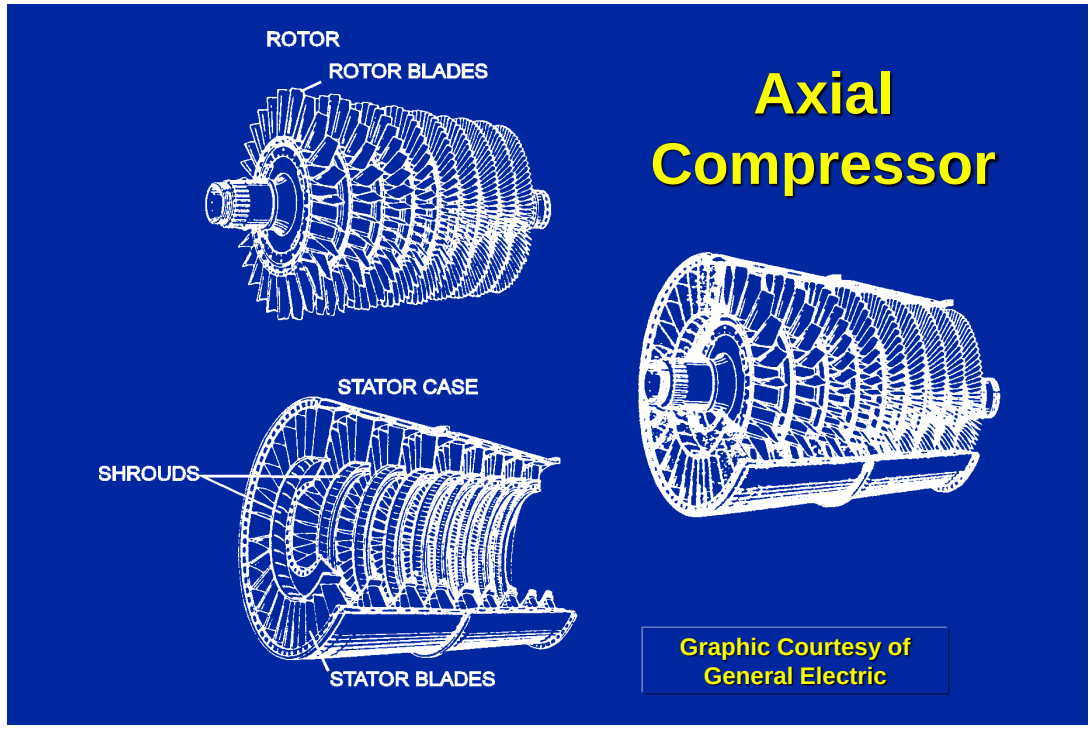

Turbine Air Inlet

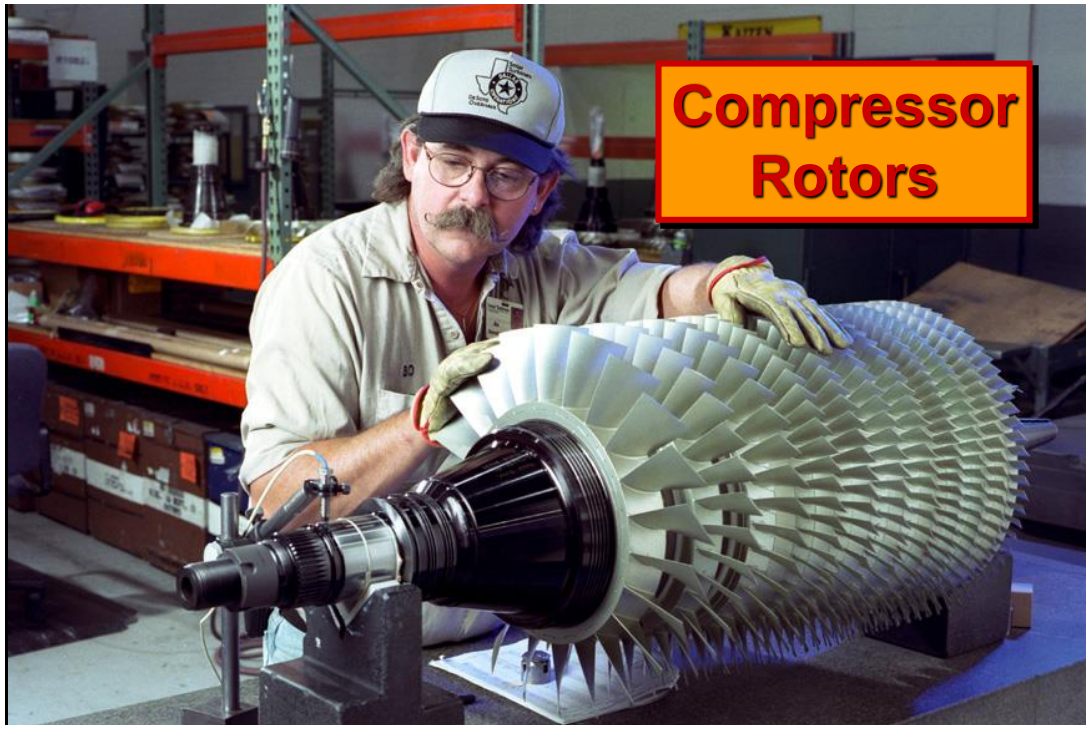

Turbine Inlet Air Filters

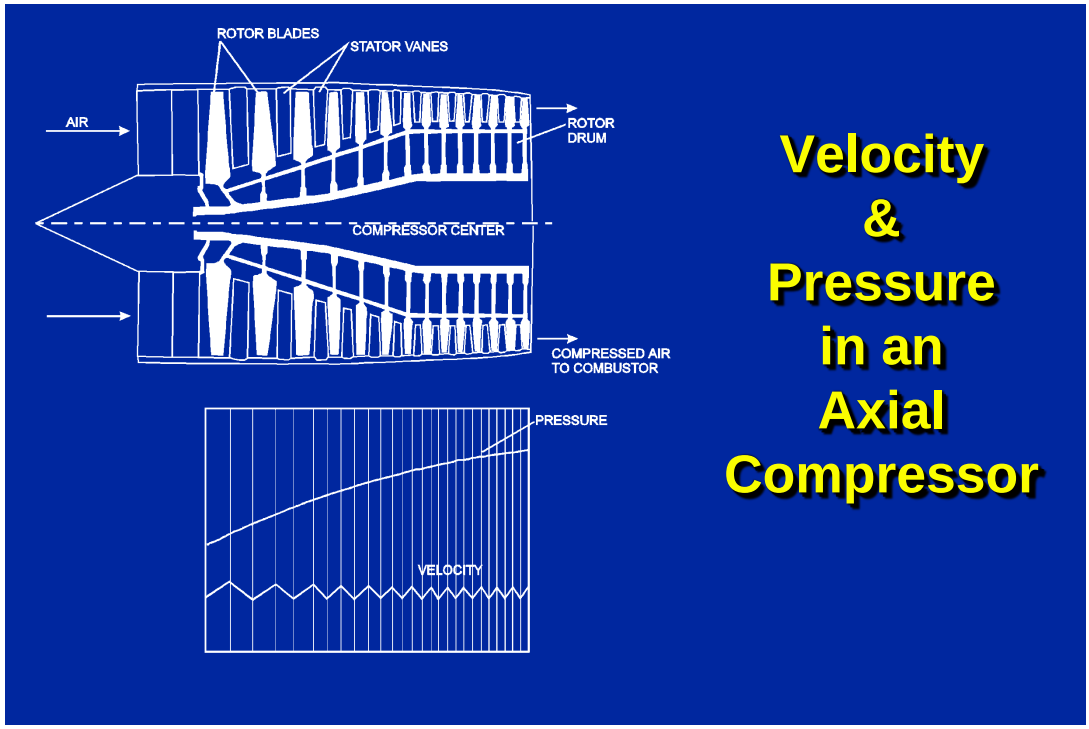

Turbine Inlet Air Filters

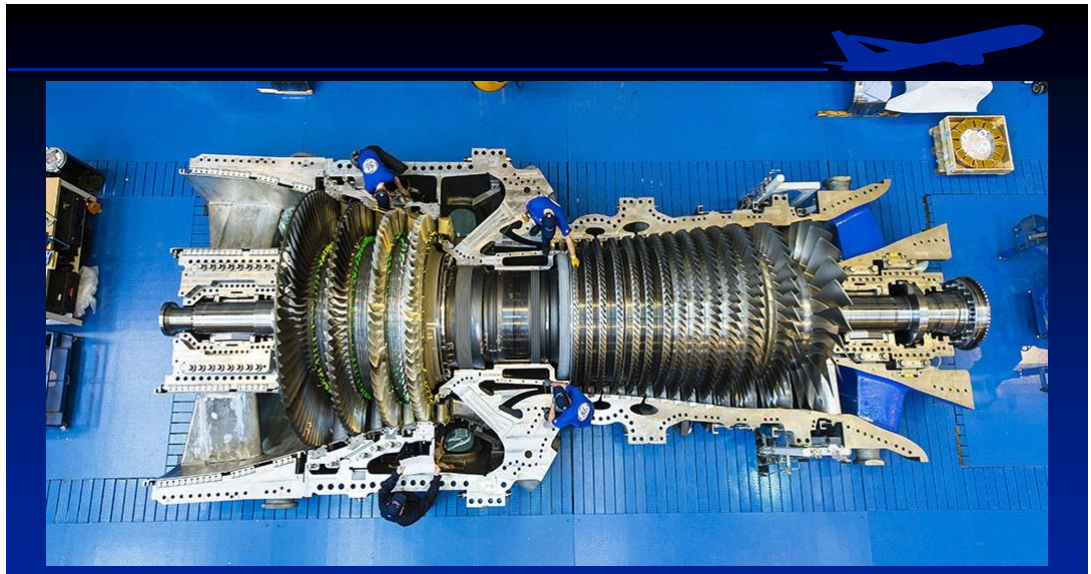

High Pressure
Water Line
Air Filter Chamber


Compressor Section


ROTOR
ROTOR BLADES
STATOR CASE
SHROUDS
STATOR BLADES
Axial Compressor
Graphic Courtesy of General Electric


Compressor
Rotors

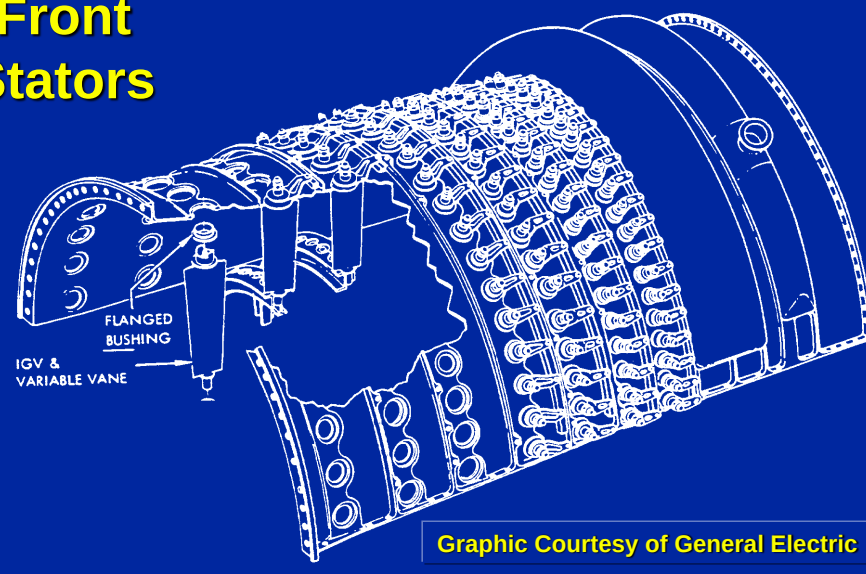

ROTOR BLADES
STATOR VANES
AIR
ROTOR
DRUM
COMPRESSOR CENTER
COMPRESSED AIR
TO COMBUSTOR
PRESSURE
VELOCITY
Velocity
&
Pressure
in an
Axial
Compressor



General Electric 9HA

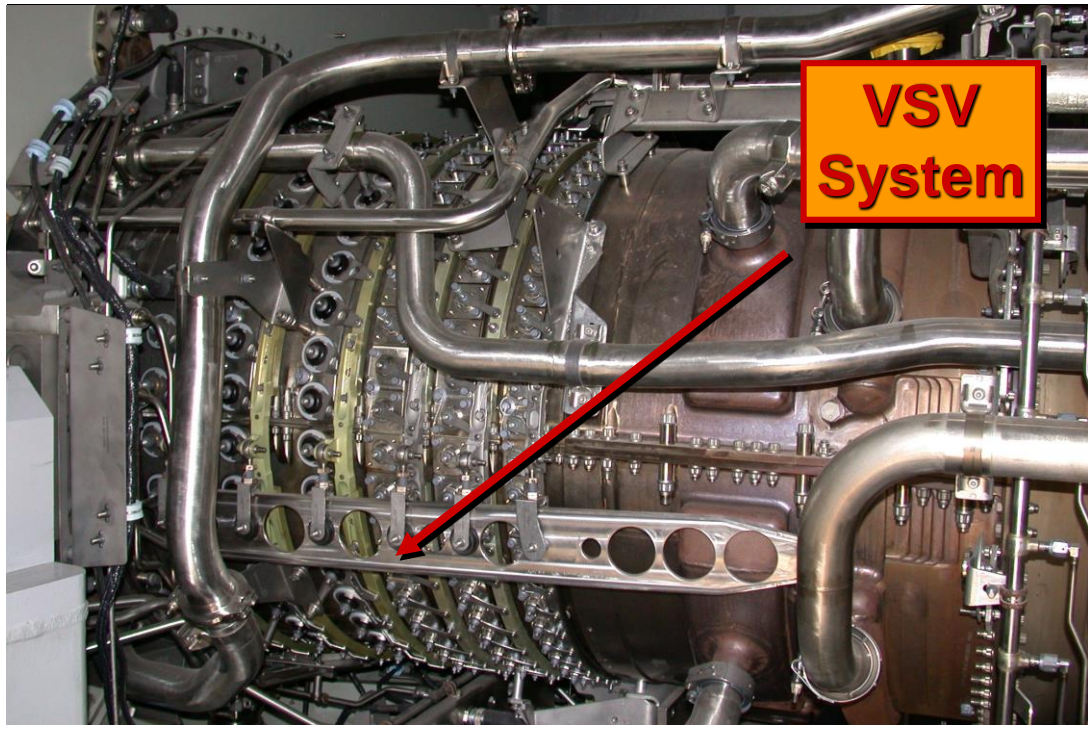
(397 MW – 532KHP)

Compressor Front Stators

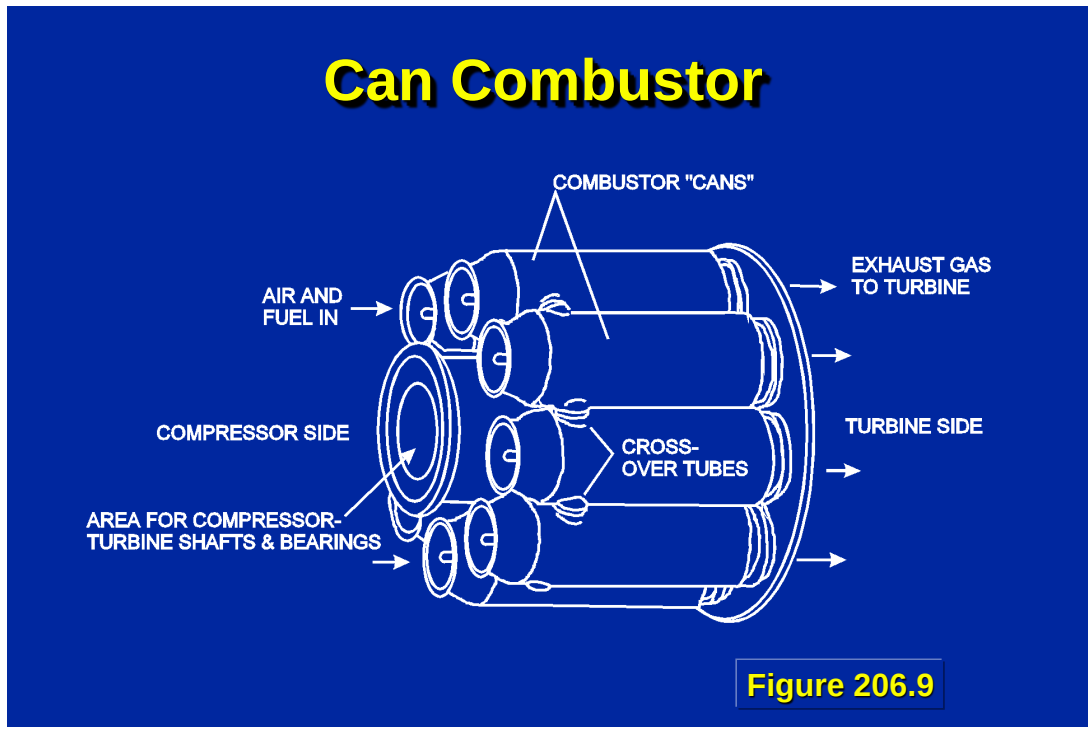


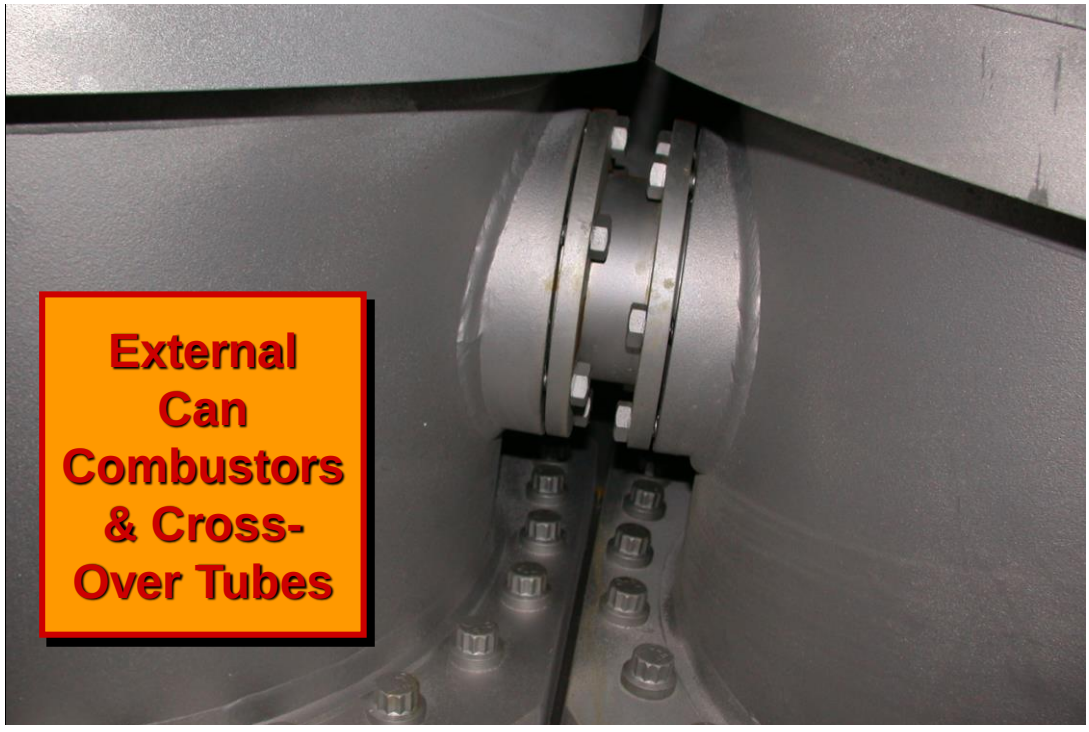
Graphic Courtesy of General Electric


Front
Stators

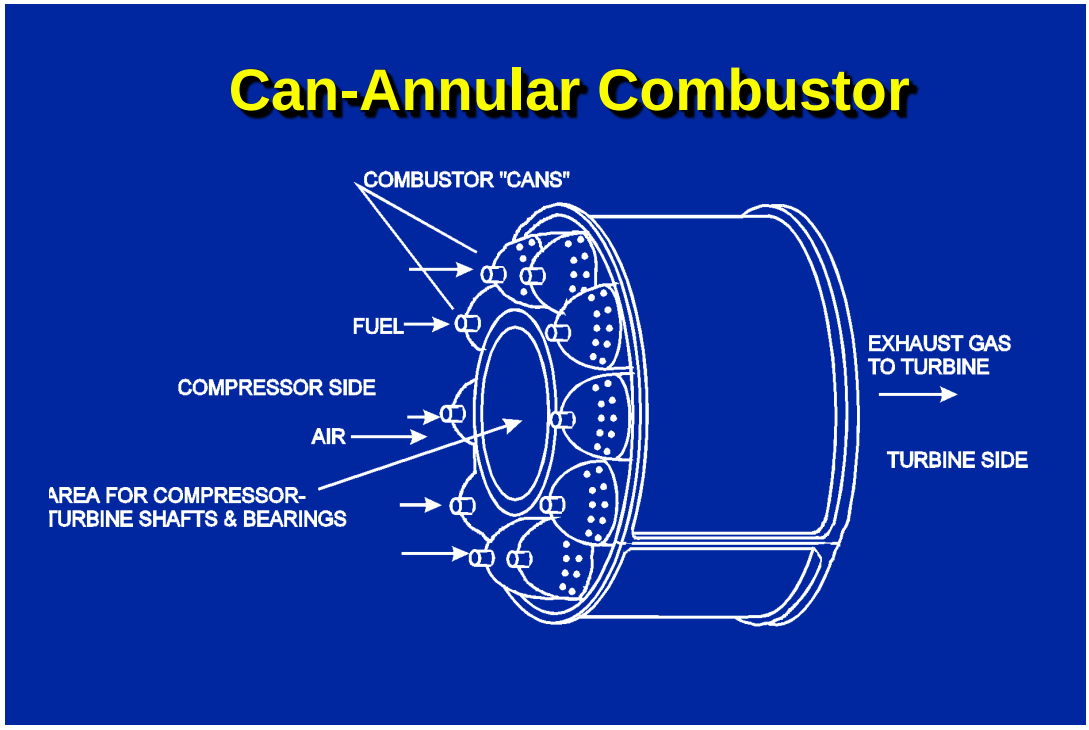

VSV
System

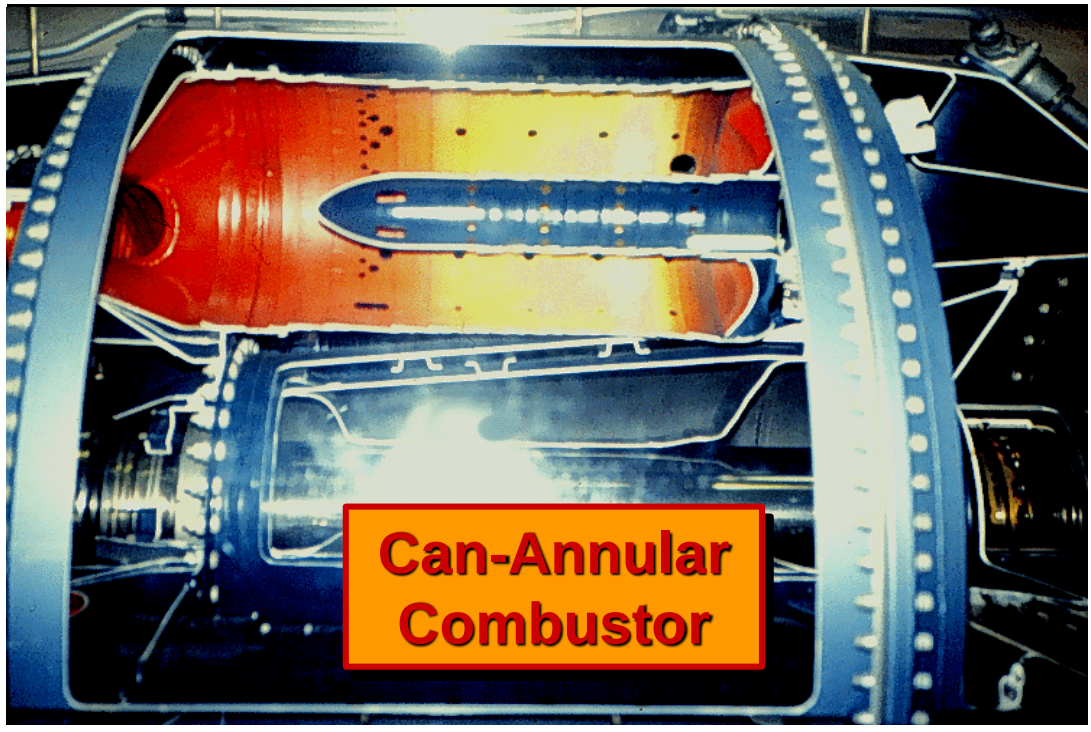

Combustor Section


Can Combustor
COMBUSTOR "CANS"
AIR AND FUEL IN
EXHAUST GAS TO TURBINE
COMPRESSOR SIDE
TURBINE SIDE
CROSS-OVER TUBES
AREA FOR COMPRESSOR-TURBINE SHAFTS & BEARINGS
Figure 206.9

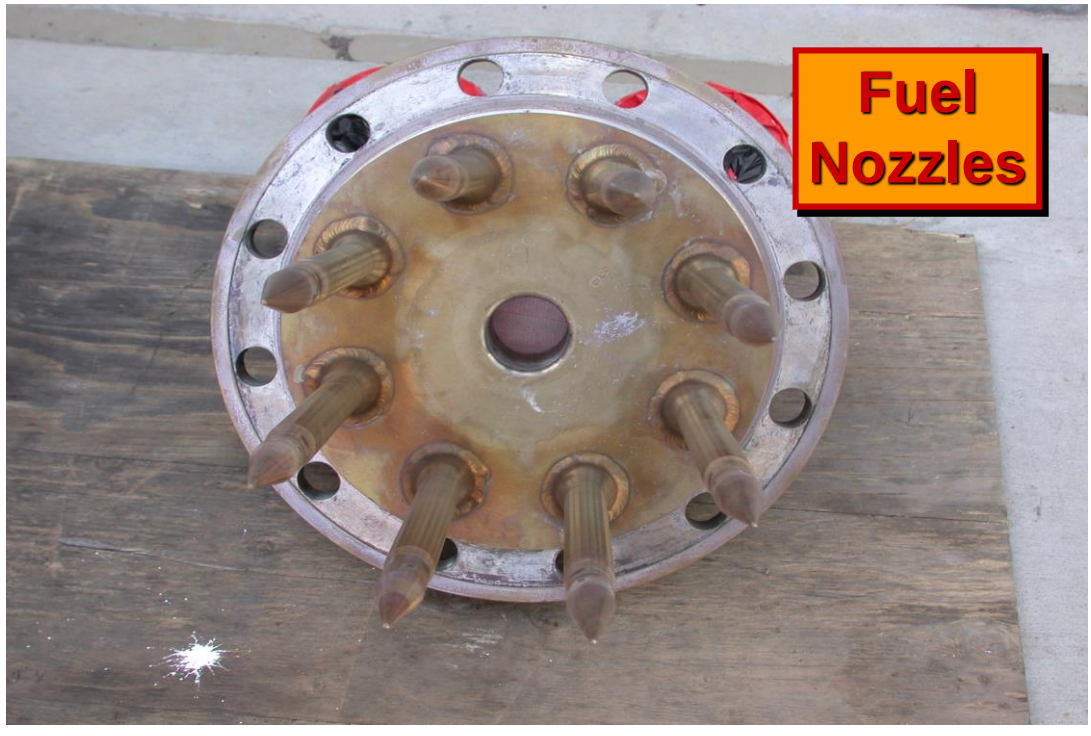

External
Can
Combustors
& Cross-
Over Tubes

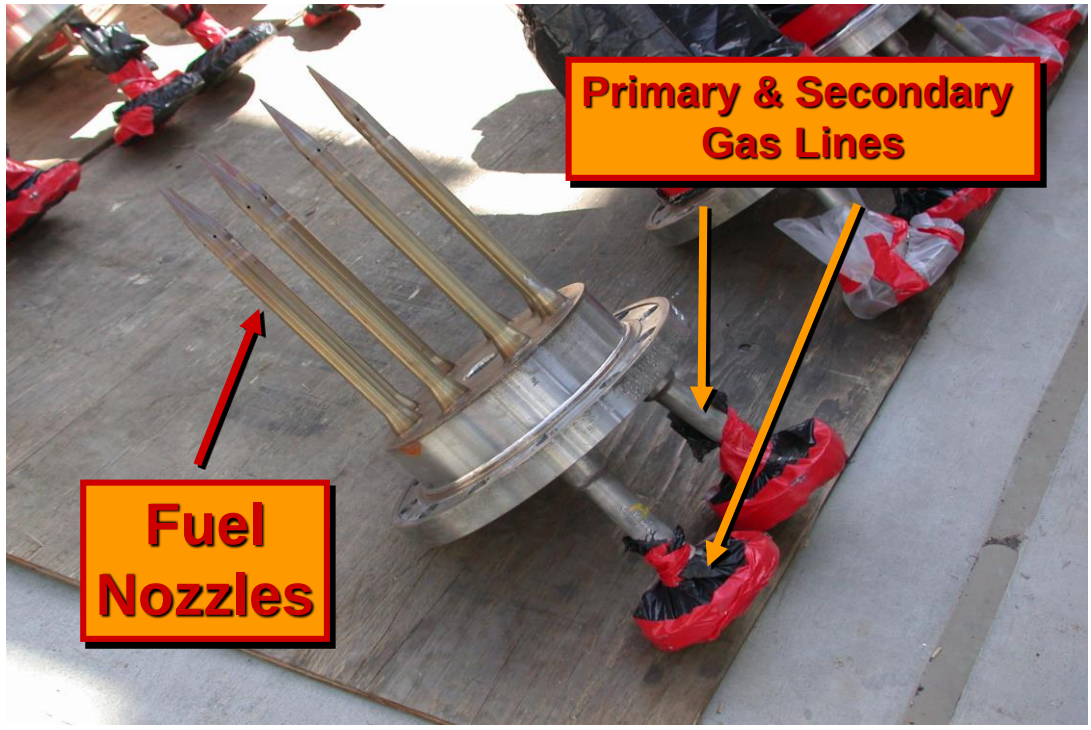

Can Combustors
& Thermocouple

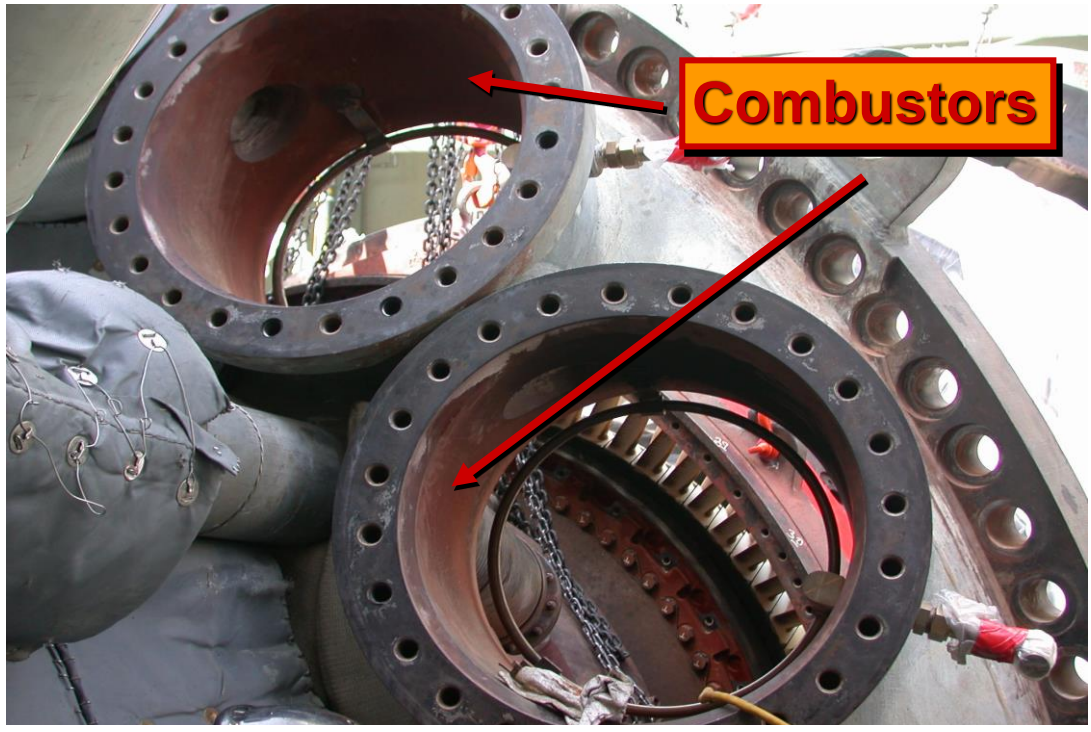

Can-Annular Combustor
COMBUSTOR "CANS"
FUEL
COMPRESSOR SIDE
AIR
AREA FOR COMPRESSOR-
TURBINE SHAFTS & BEARINGS
EXHAUST GAS
TO TURBINE
TURBINE SIDE

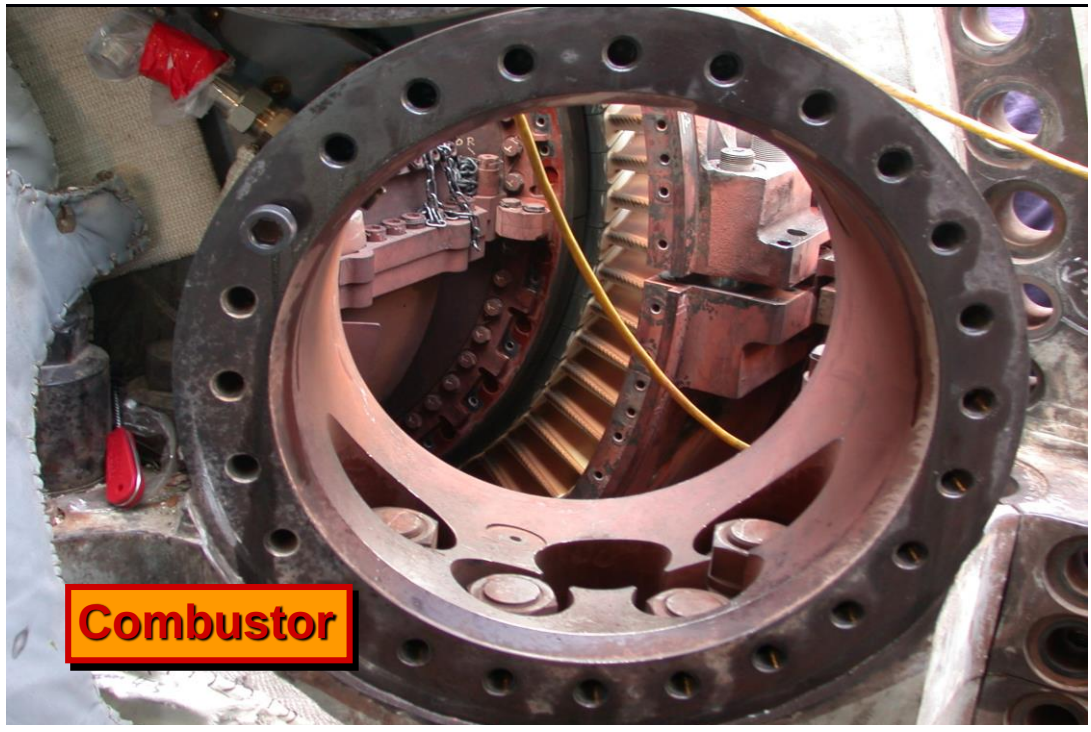

Can-Annular
Combustor

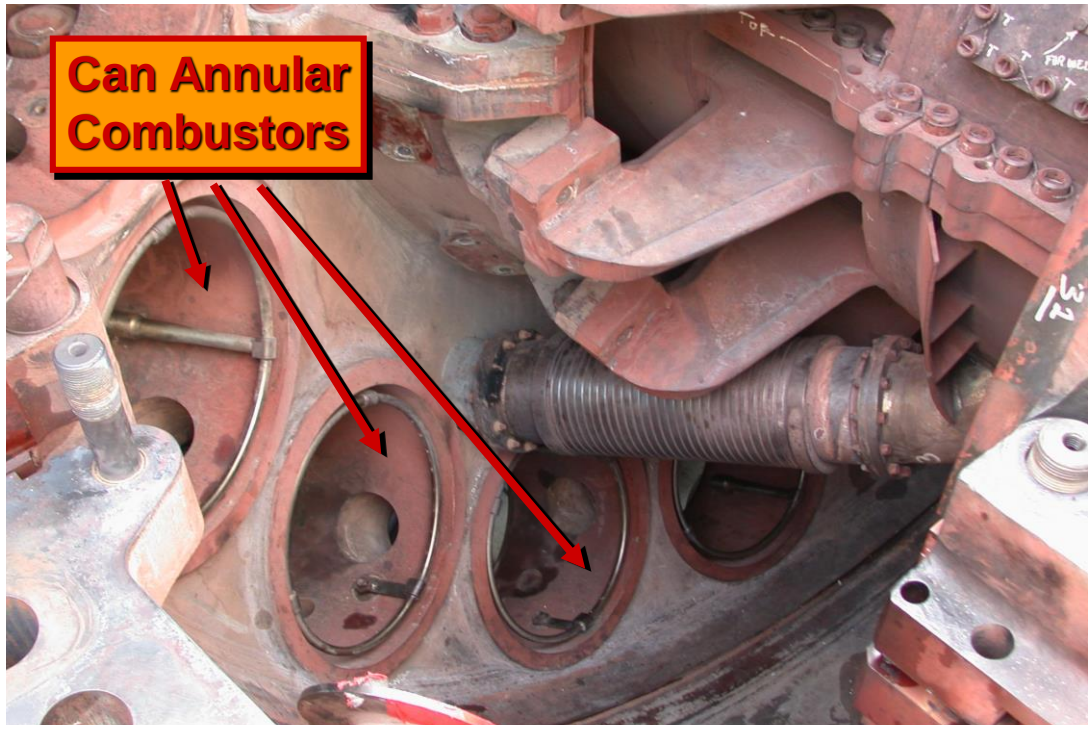

Can-Annular Lean
Premix Burner

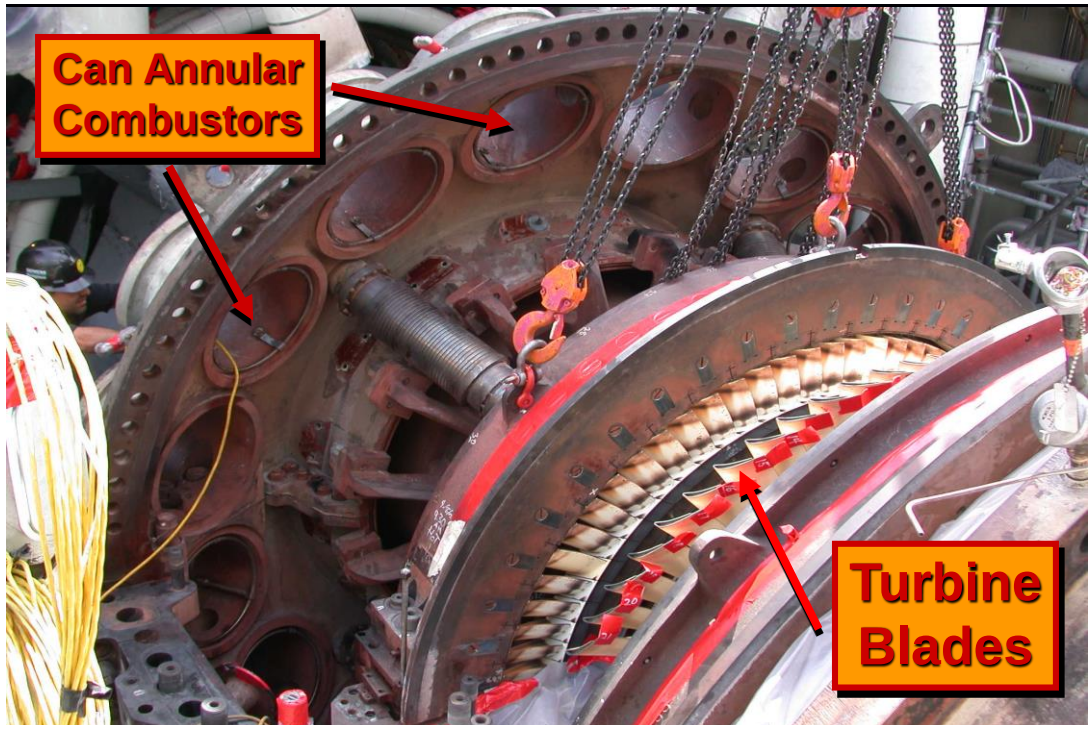

Fuel
Nozzles

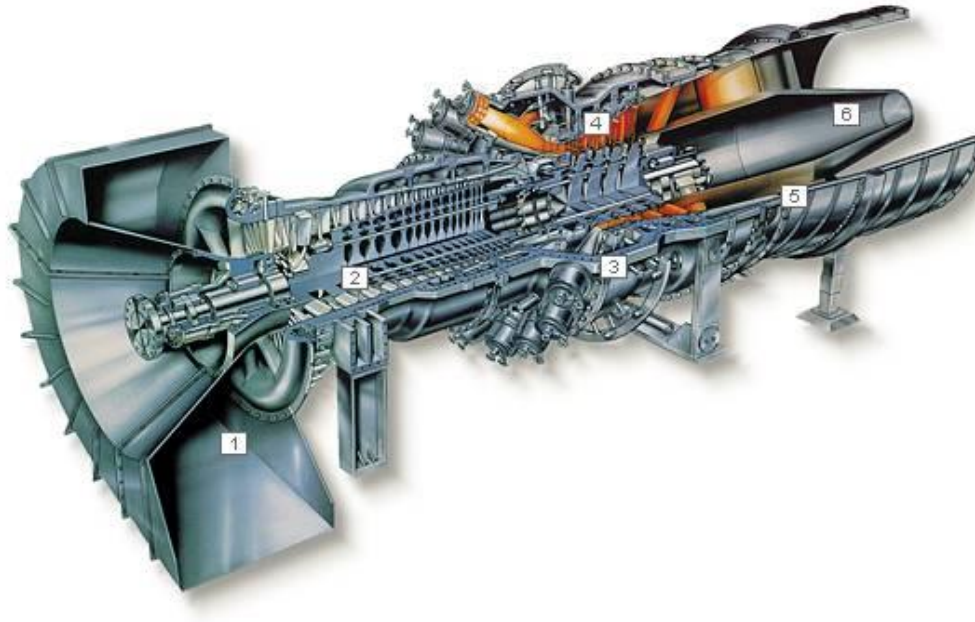

Primary & Secondary Gas Lines
Fuel Nozzles

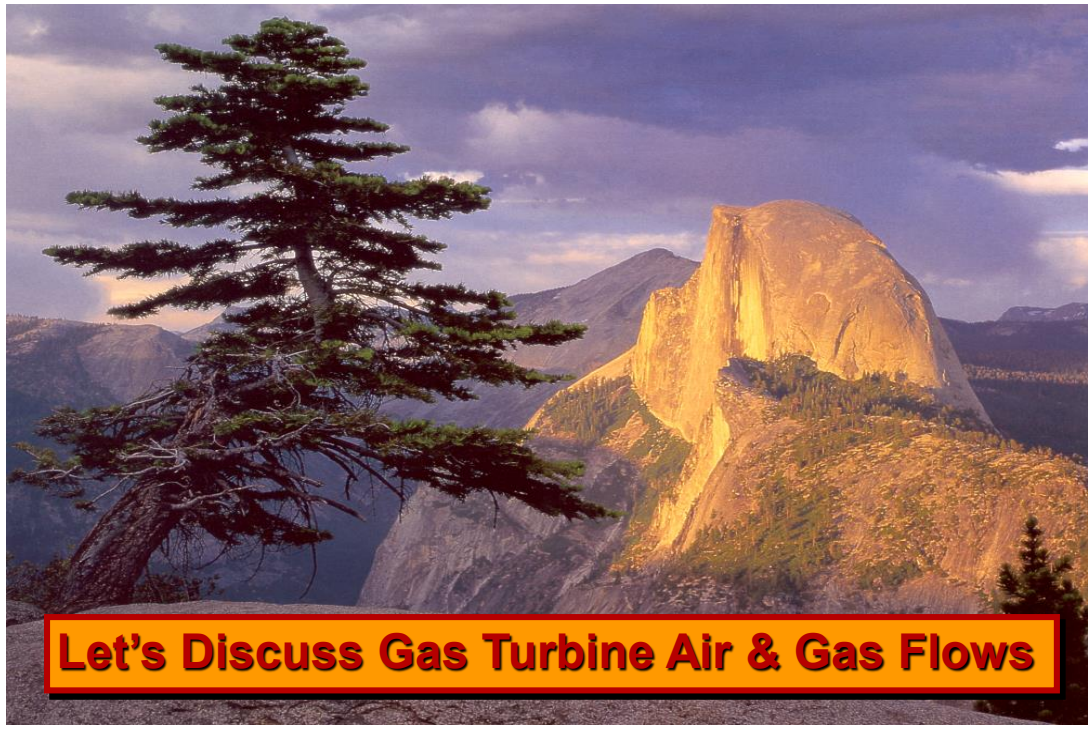

Combustors


Combustor

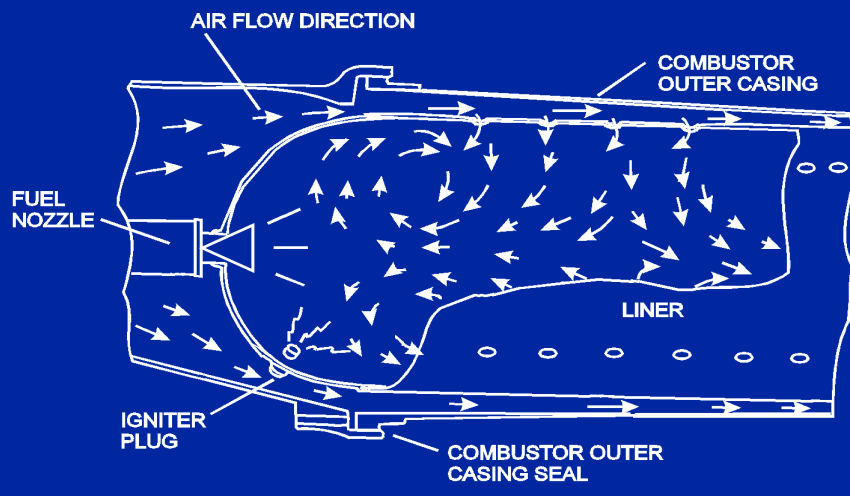

Can Annular
Combustors

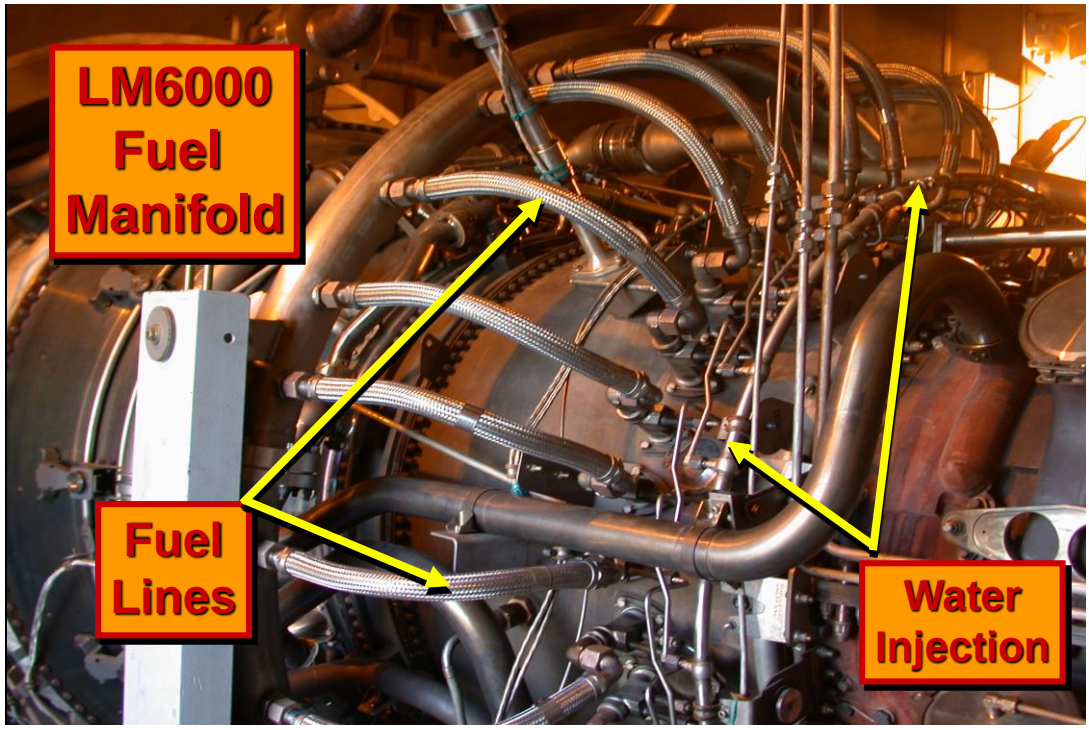

Can Annular Combustors
Turbine Blades

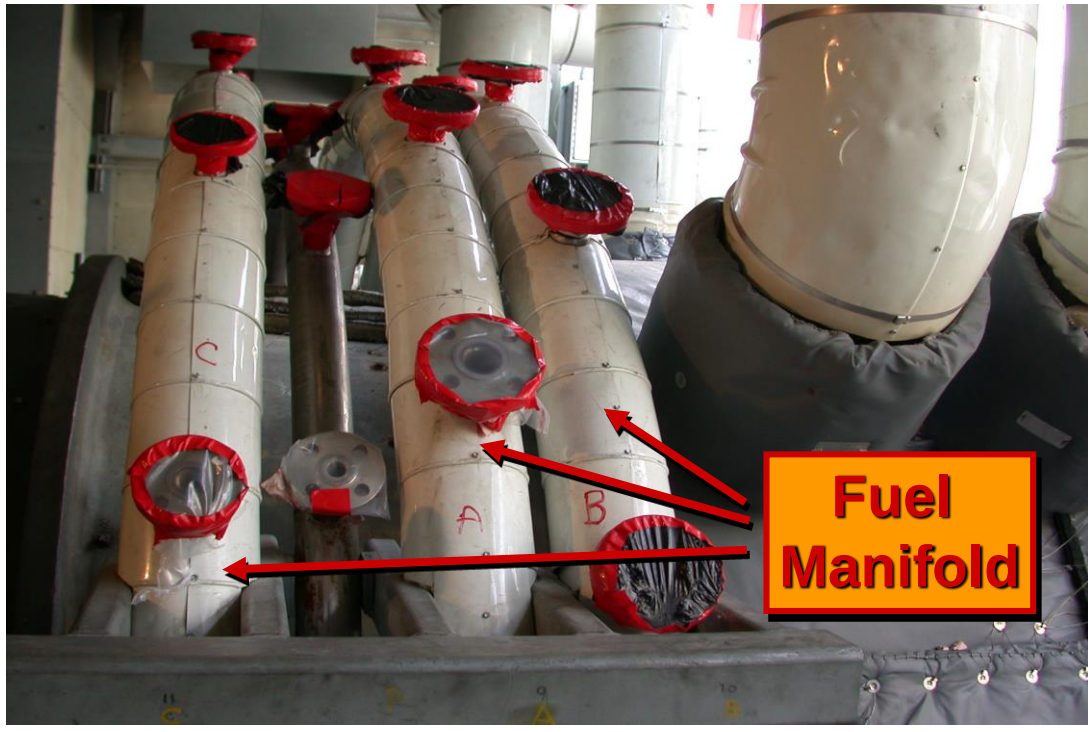

1
2
3
4
5
6



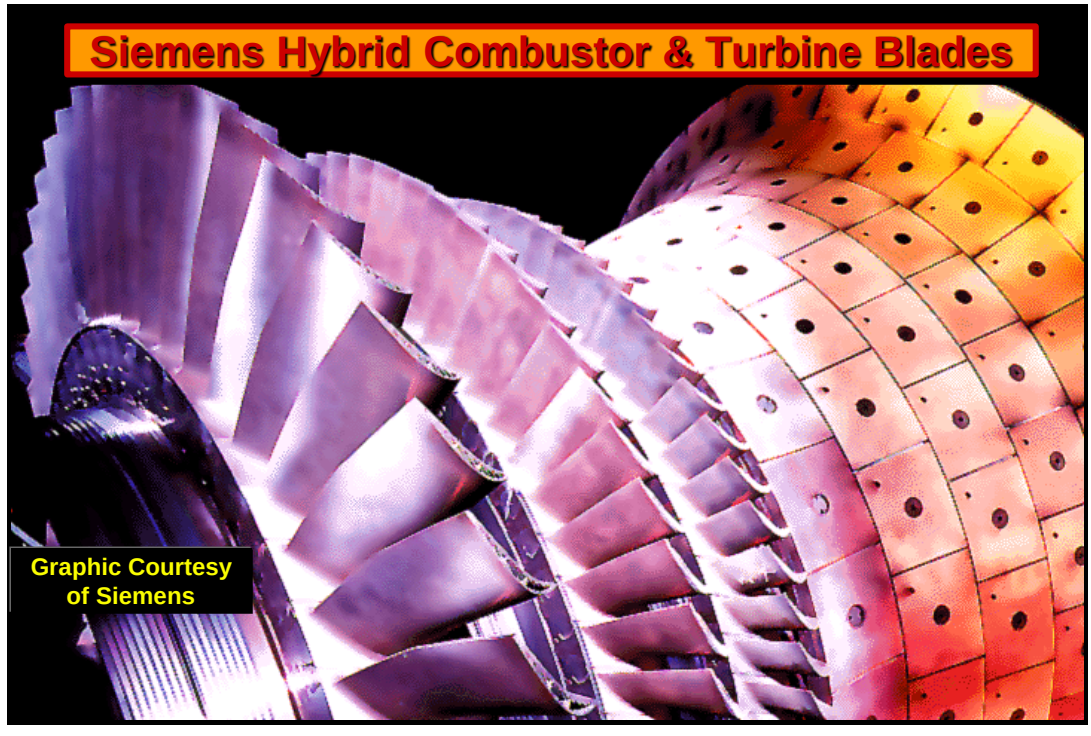
Combustor Liner and Air Flow

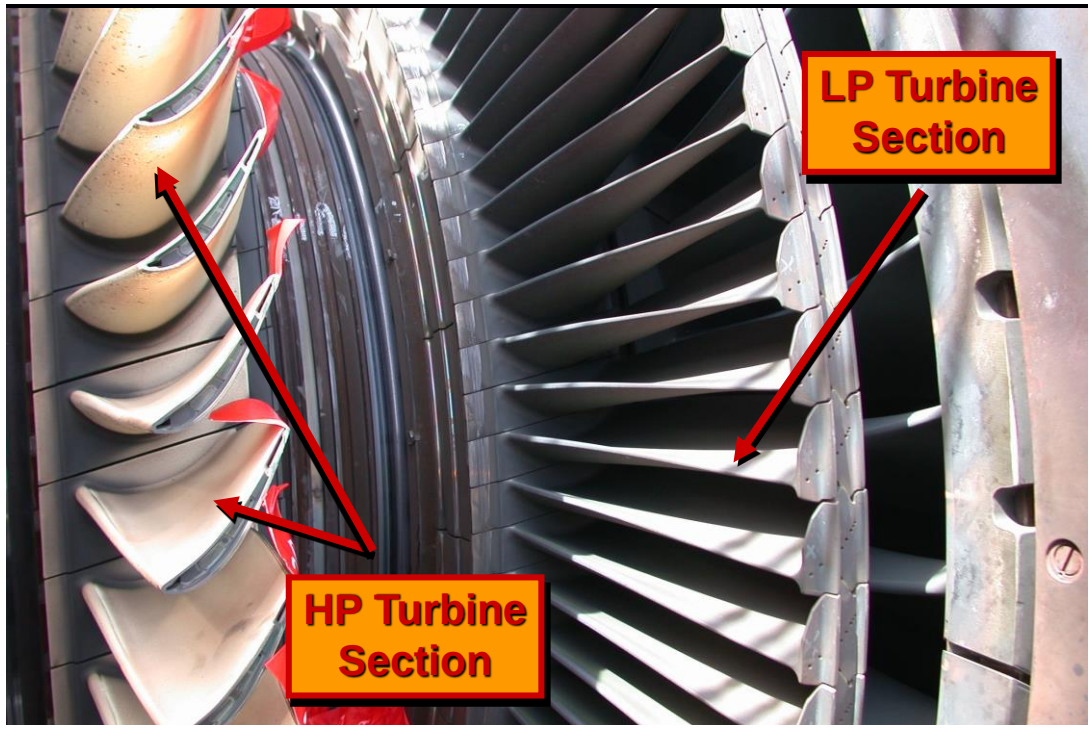


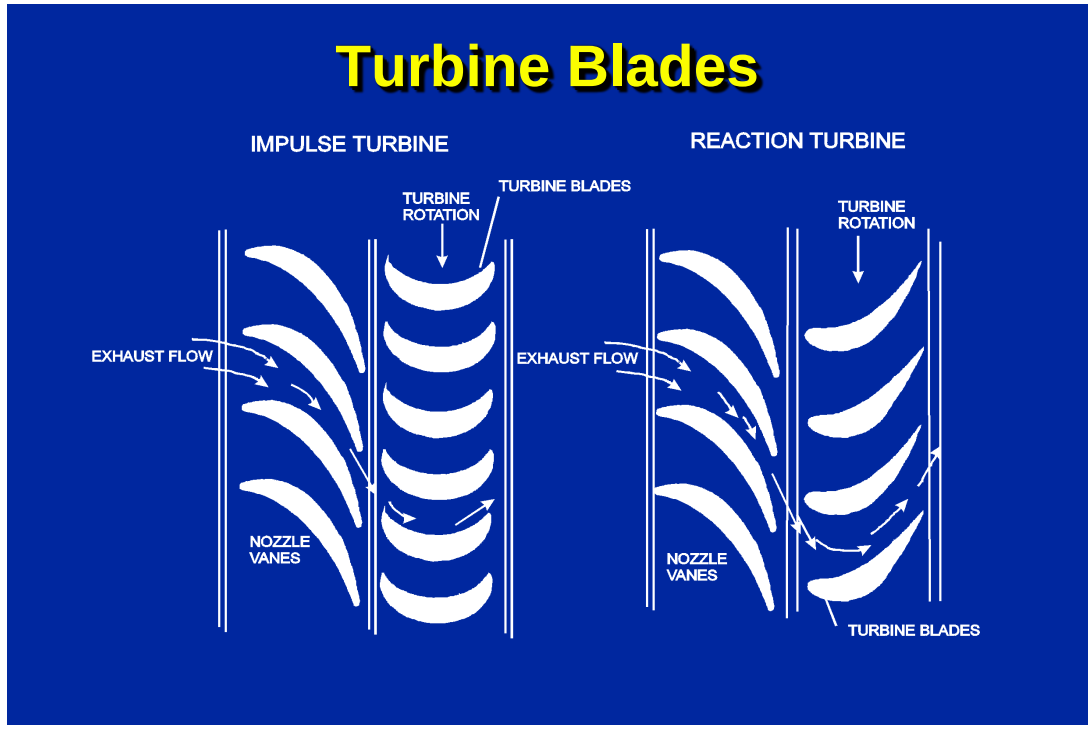

LM6000
Fuel
Manifold
Fuel
Lines
Water
Injection

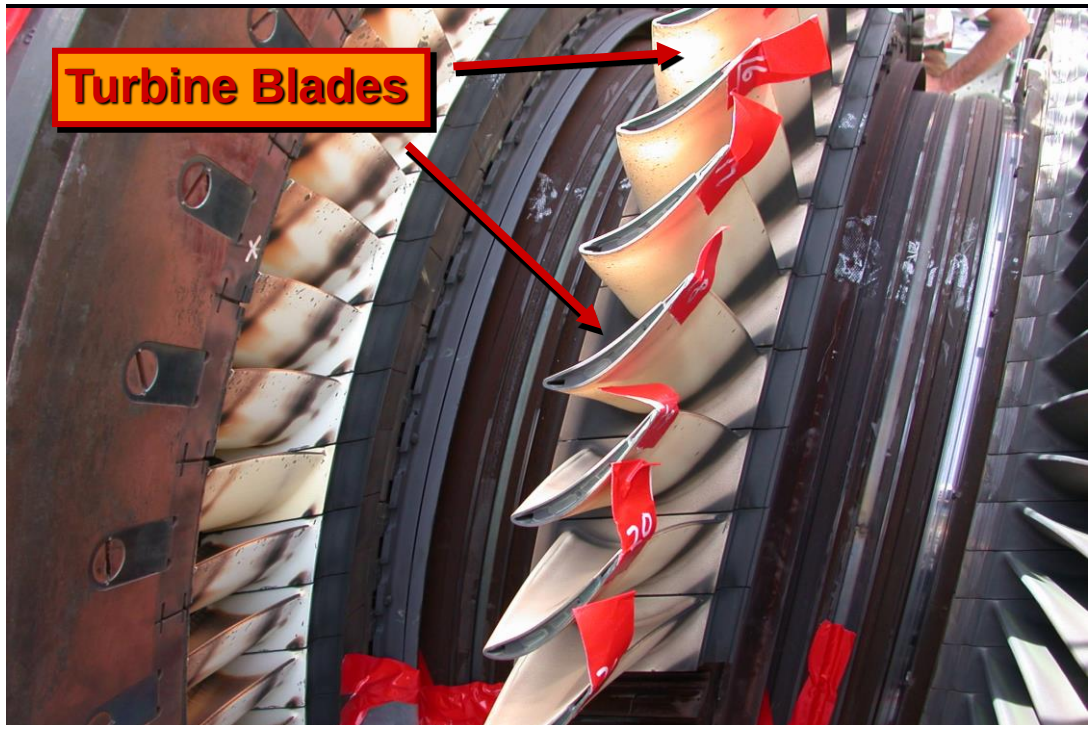

Fuel
Manifold


Let's Discuss Turbine Sections


Siemens Hybrid Combustor & Turbine Blades
Graphic Courtesy of Siemens


LP Turbine Section
HP Turbine Section


Turbine Blades
IMPULSE TURBINE
REACTION TURBINE
TURBINE ROTATION
TURBINE BLADES
EXHAUST FLOW
NOZZLE VANES
TURBINE ROTATION
EXHAUST FLOW
NOZZLE VANES
TURBINE BLADES

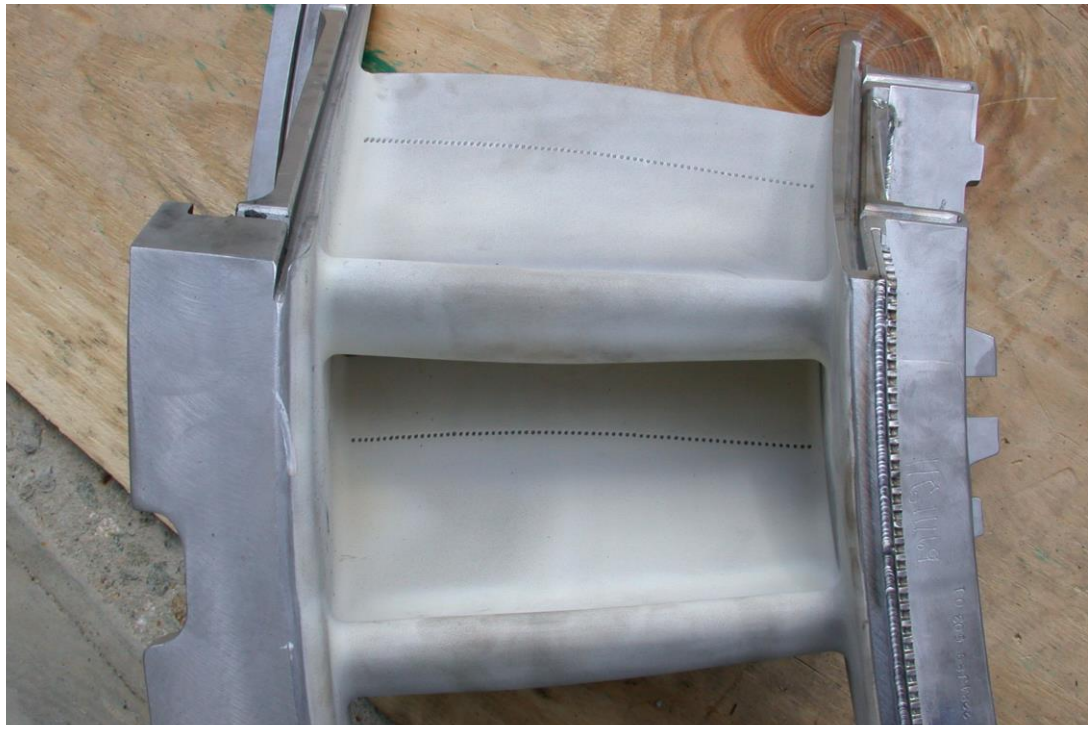

Turbine Blades


Turbine
Discs


Turbine Blades


Turbine Disc


Let's Discuss Turbine Air Cooling




Inlet Air Cooling

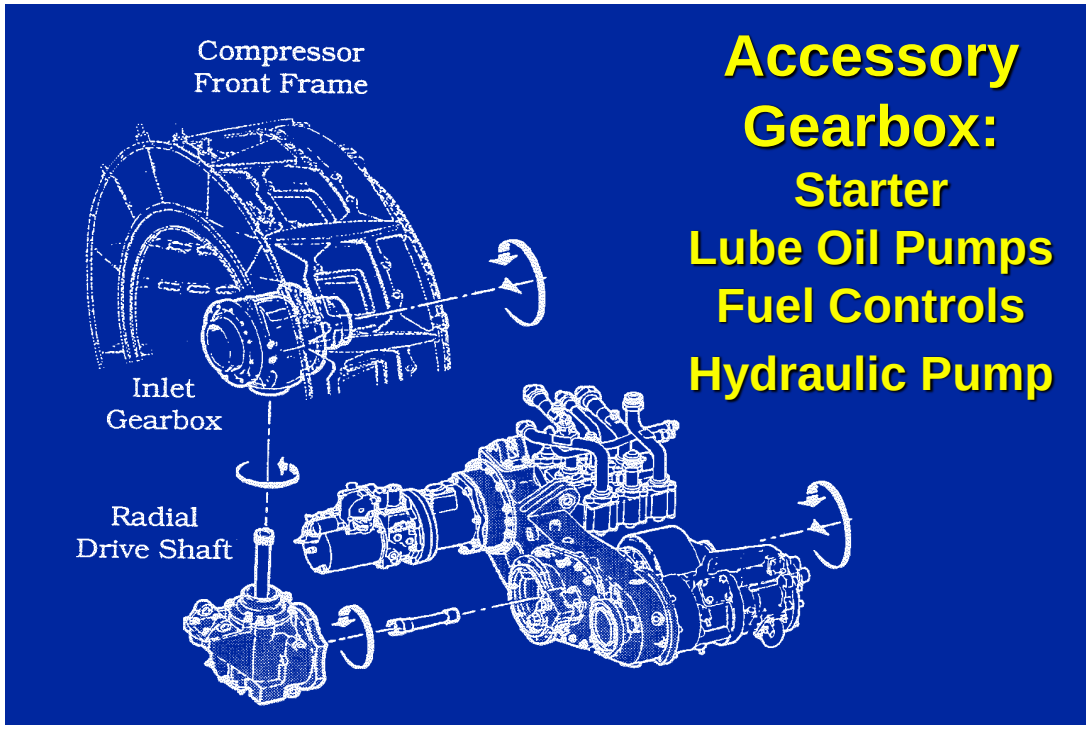

Turbine Lube
Oil System

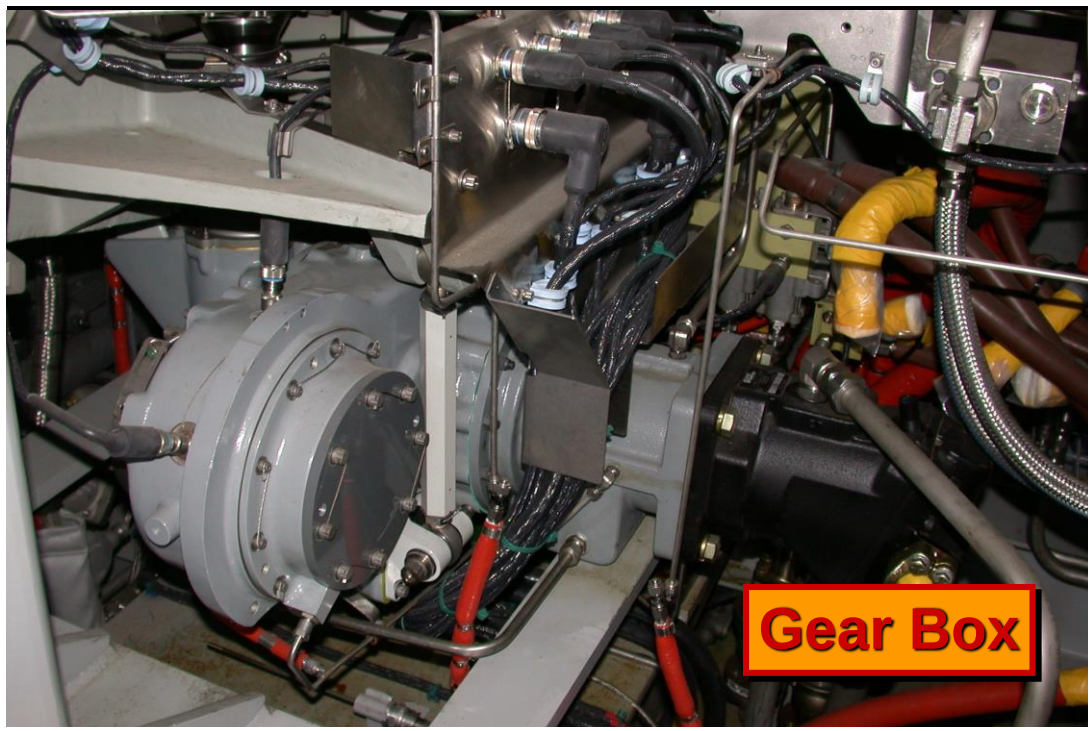

Lube Oil Pump

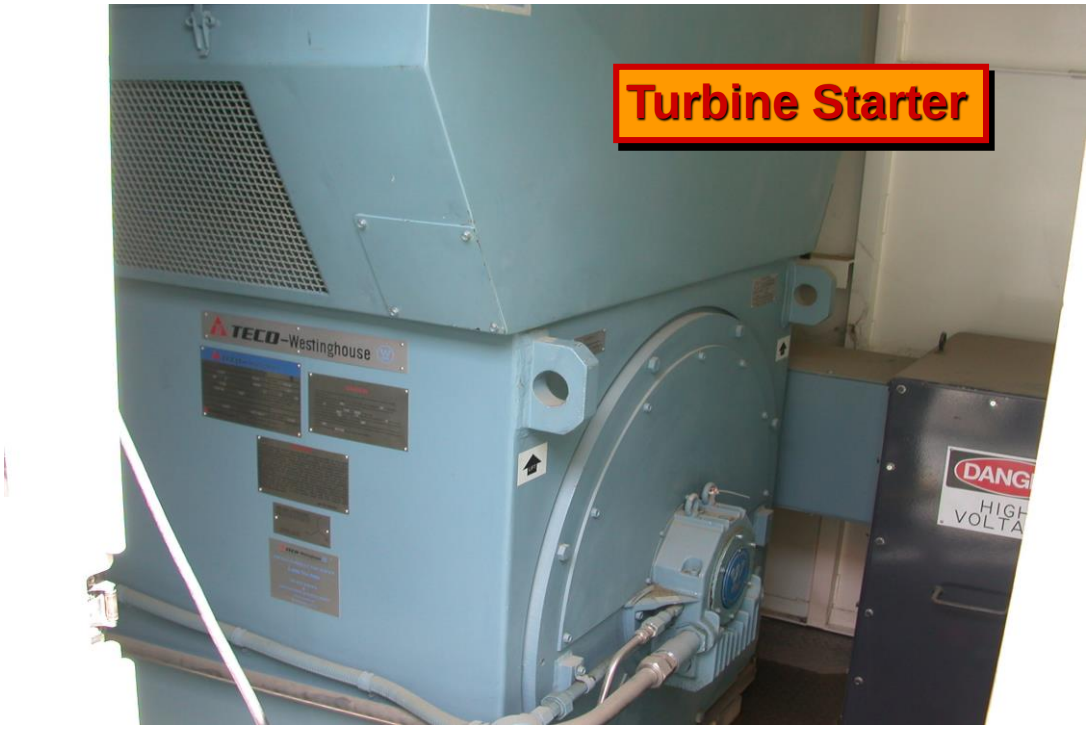

Lube Oil Pump
to Turbine


Lube Oil Air Cooling


Air-Oil
Separator
Exhaust

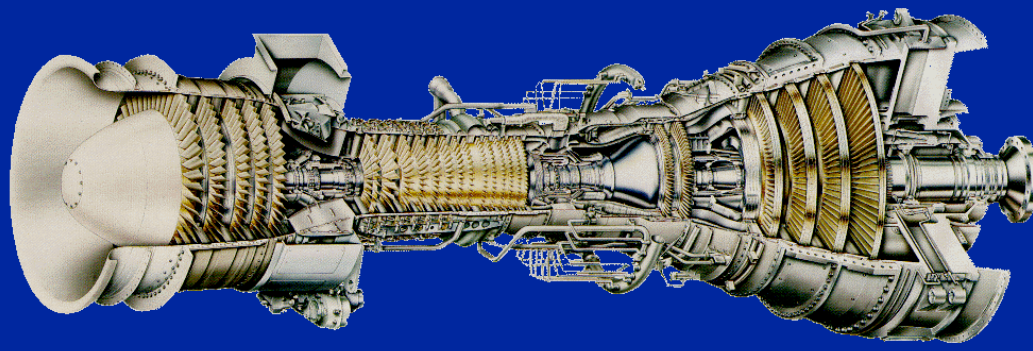

Compressor
Front Frame
Inlet
Gearbox
Radial
Drive Shaft
Accessory
Gearbox:
Starter
Lube Oil Pumps
Fuel Controls
Hydraulic Pump


Gear Box

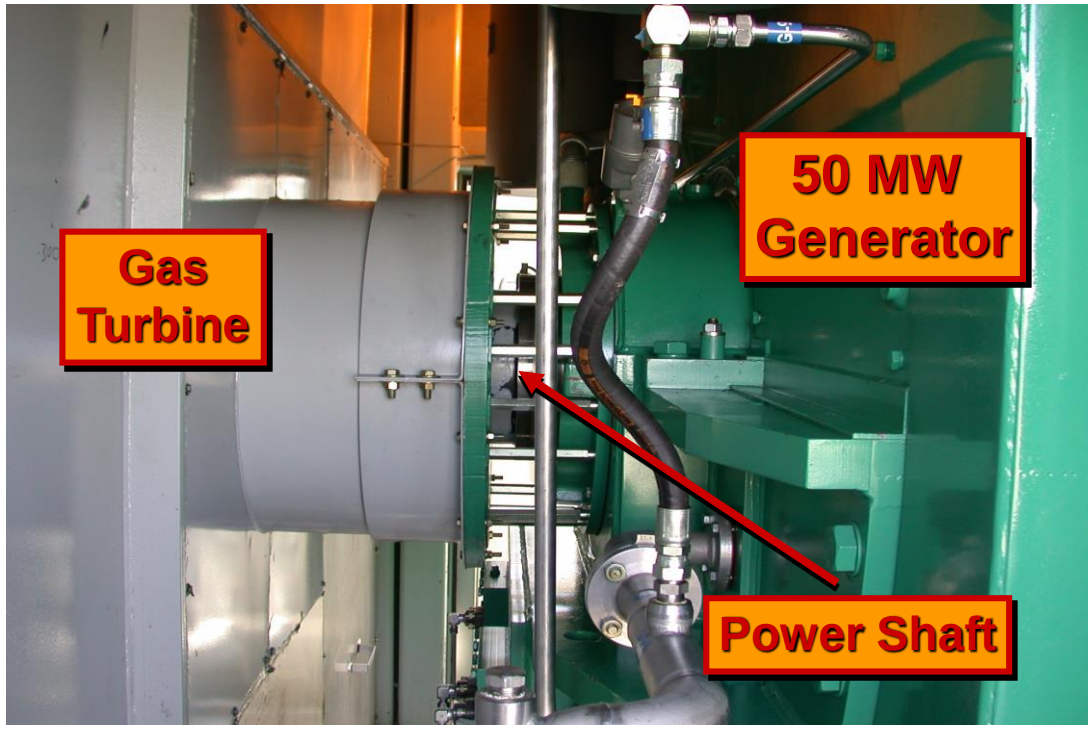

Turbine Starter
TECO-Westinghouse

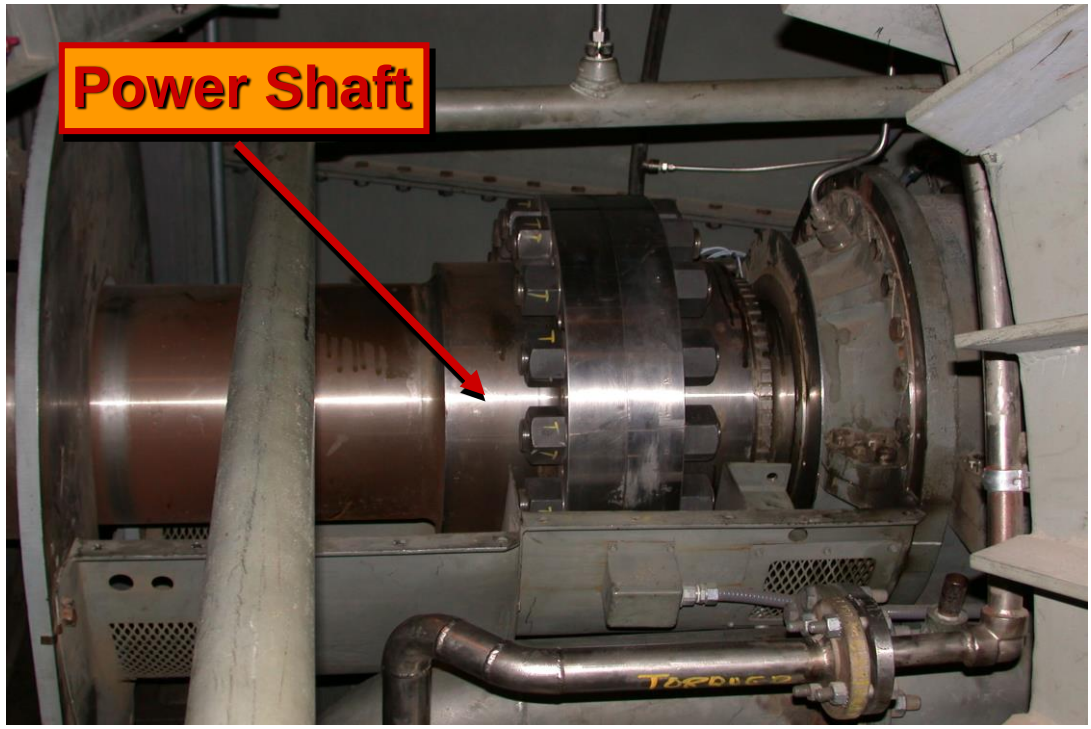

Let's have some fun!!

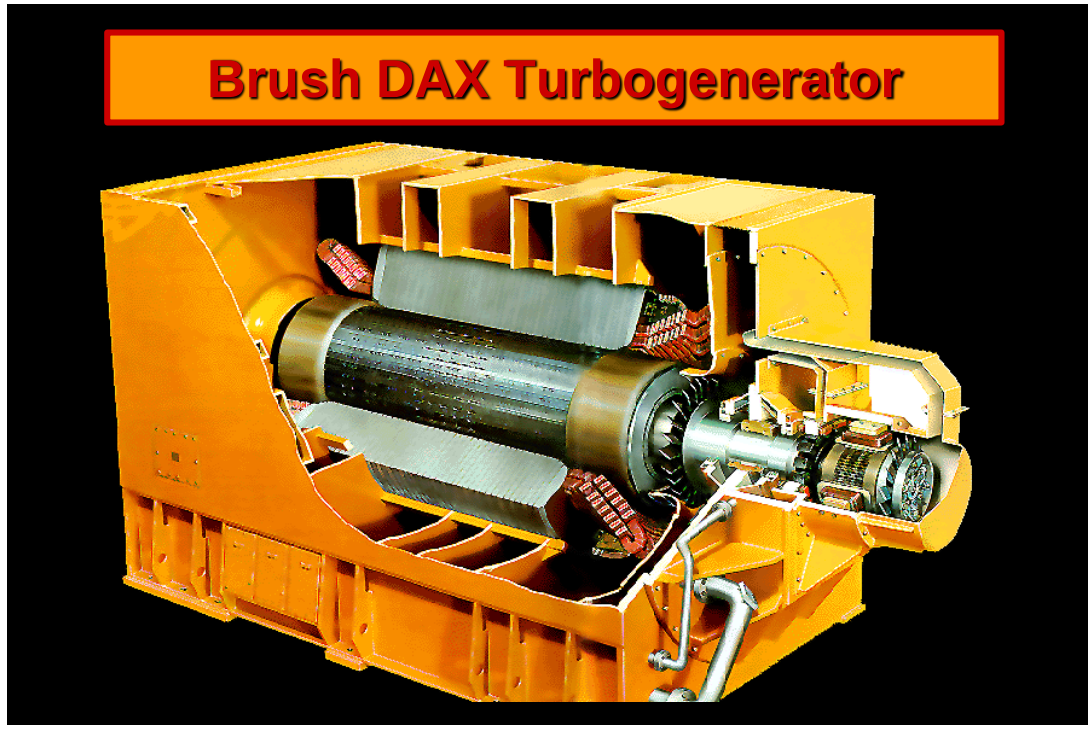
GE LM6000 Gas Turbine



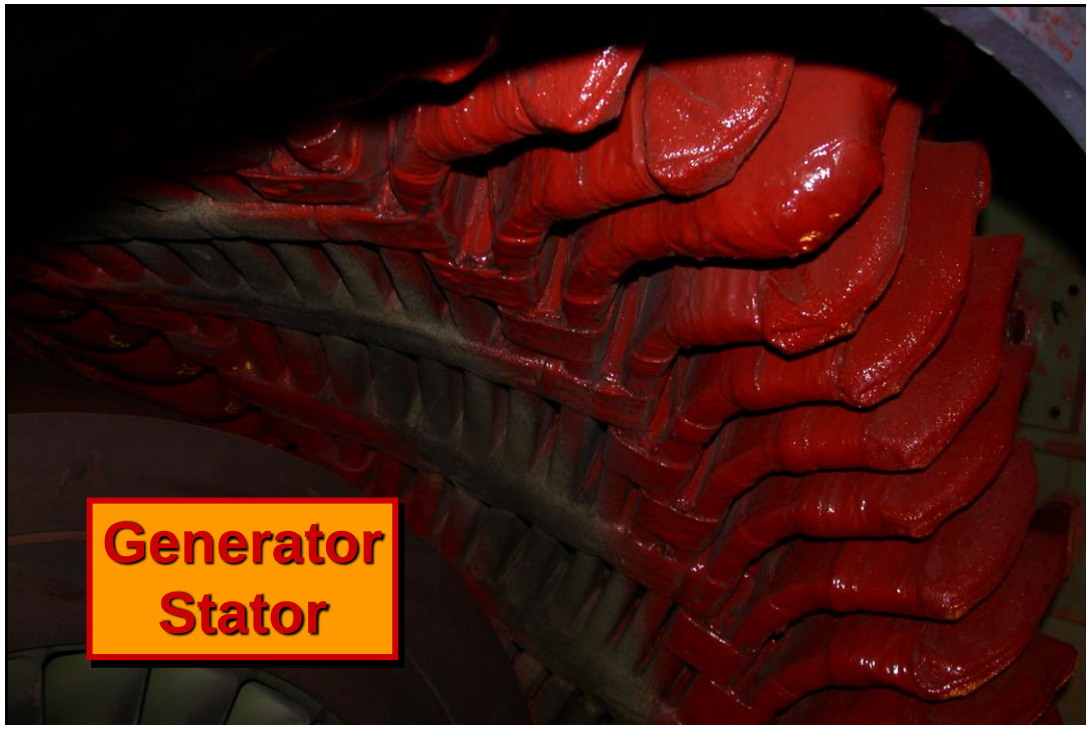
Exercise


Gas Turbine
50 MW Generator
Power Shaft


Power Shaft

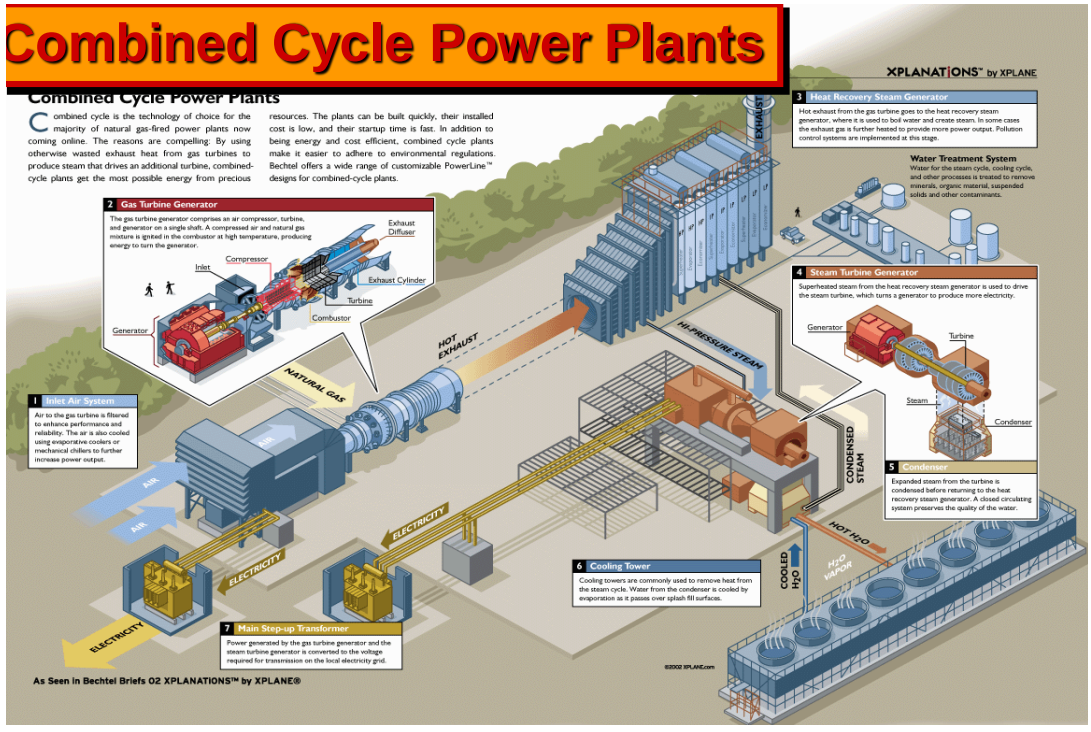

Brush DAX Turbogenerator


Generator
Rotor

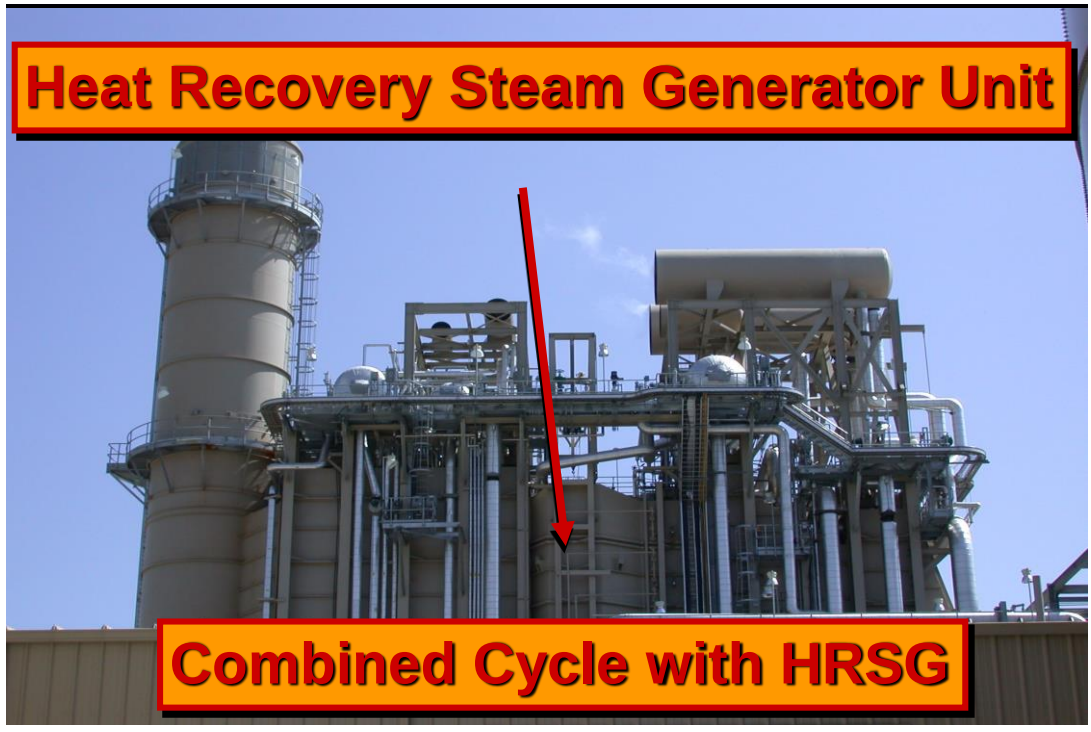

Generator
Stator

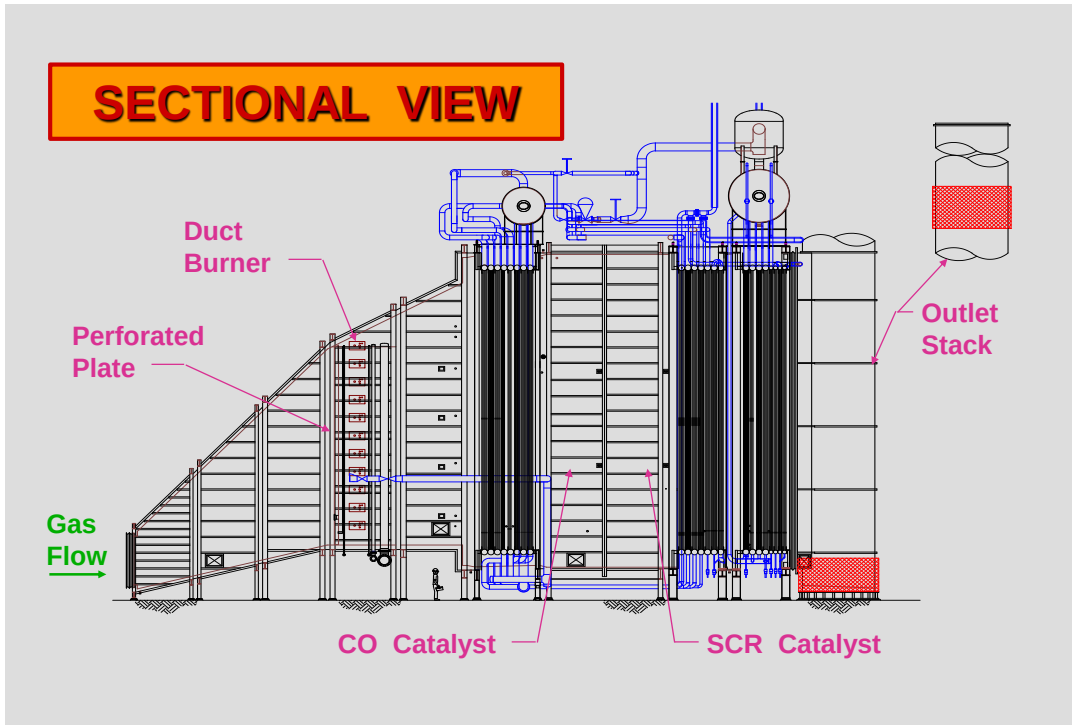

Step-up Transformers


Let's Discuss
Steam Generation

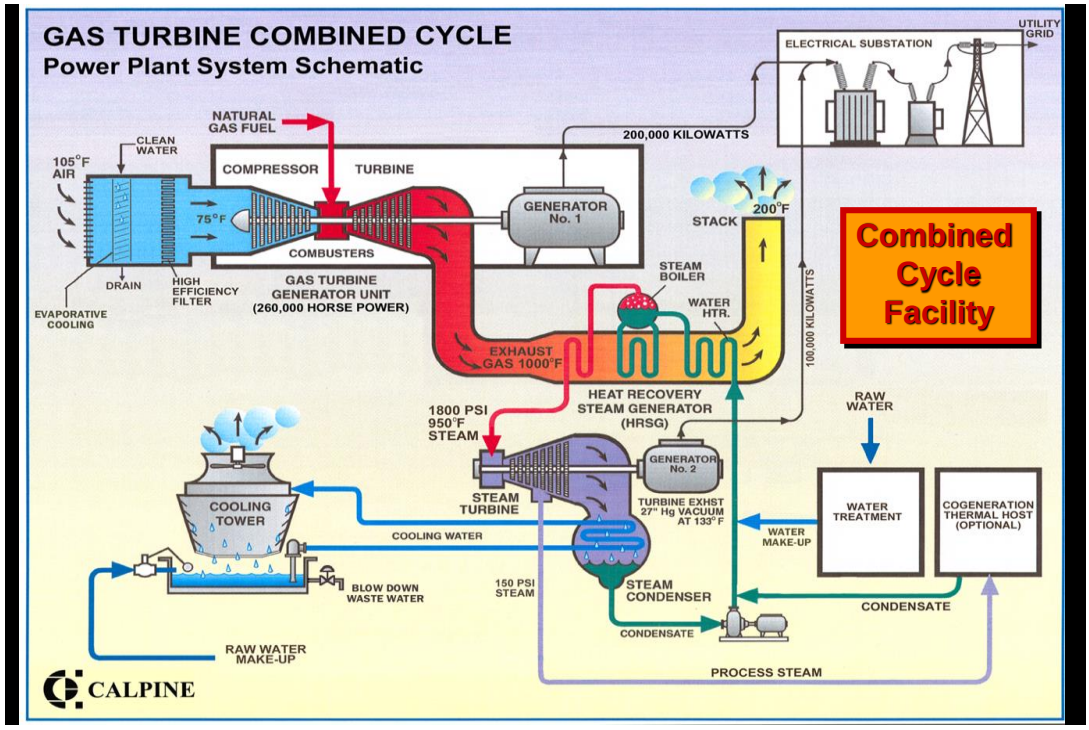

Combined Cycle Power Plants
XPLANATIONS™ by XPLANE
Combined Cycle Power Plants
Combined cycle is the technology of choice for the majority of natural gas-fired power plants now coming online. The reasons are compelling: By using otherwise wasted exhaust heat from gas turbines to produce steam that drives an additional turbine, combined-cycle plants get the most possible energy from precious resources. The plants can be built quickly, their installed cost is low, and their startup time is fast. In addition to being energy and cost efficient, combined cycle plants make it easier to adhere to environmental regulations. Bechtel offers a wide range of customizable PowerLine™ designs for combined-cycle plants.
2 Gas Turbine Generator
The gas turbine generator comprises an air compressor, turbine, and generator on a single shaft. A compressed air and natural gas mixture is ignited in the combustor at high temperature, producing energy to turn the generator.
Exhaust Diffuser
Compressor
Inlet
Exhaust Cylinder
Turbine
Combustor
Generator
NATURAL GAS
HOT EXHAUST
EXHAUST
3 Heat Recovery Steam Generator
Hot exhaust from the gas turbine goes to the heat recovery steam generator, where it is used to boil water and create steam. In some cases the exhaust gas is further heated to provide more power output. Pollution control systems are implemented at this stage.
Water Treatment System
Water for the steam cycle, cooling cycle, and other processes is treated to remove minerals, organic material, suspended solids and other contaminants.
4 Steam Turbine Generator
Superheated steam from the heat recovery steam generator is used to drive the steam turbine, which turns a generator to produce more electricity.
Generator
Turbine
Steam
Condenser
HI-PRESSURE STEAM
CONDENSED STEAM
5 Condenser
Expanded steam from the turbine is condensed before returning to the heat recovery steam generator. A closed circulating system preserves the quality of the water.
1 Inlet Air System
Air to the gas turbine is filtered to enhance performance and reliability. The air is also cooled using evaporative coolers or mechanical chillers to further increase power output.
AIR
AIR
ELECTRICITY
ELECTRICITY
ELECTRICITY
7 Main Step-up Transformer
Power generated by the gas turbine generator and the steam turbine generator is converted to the voltage required for transmission on the local electricity grid.
6 Cooling Tower
Cooling towers are commonly used to remove heat from the steam cycle. Water from the condenser is cooled by evaporation as it passes over splash fill surfaces.
HOT H2O
COOLED H2O
H2O VAPOR
As Seen in Bechtel Briefs 02 XPLANATIONS™ by XPLANE®

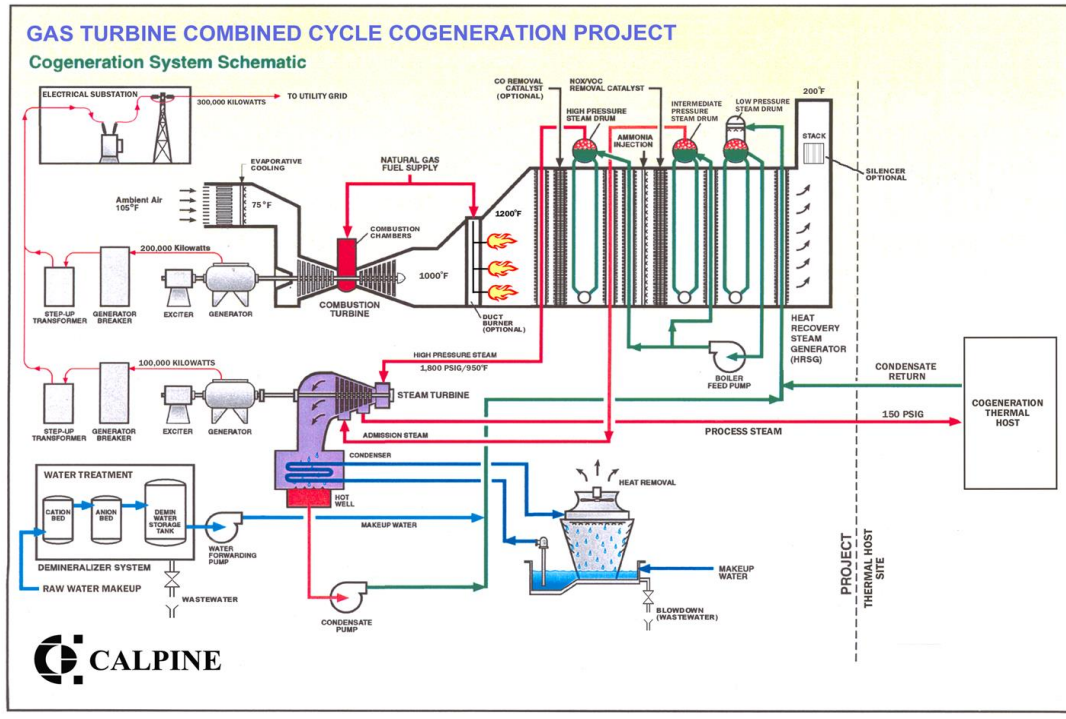

Combined Cycle Power Plant


Heat Recovery Steam Generator Unit
Combined Cycle with HRSG

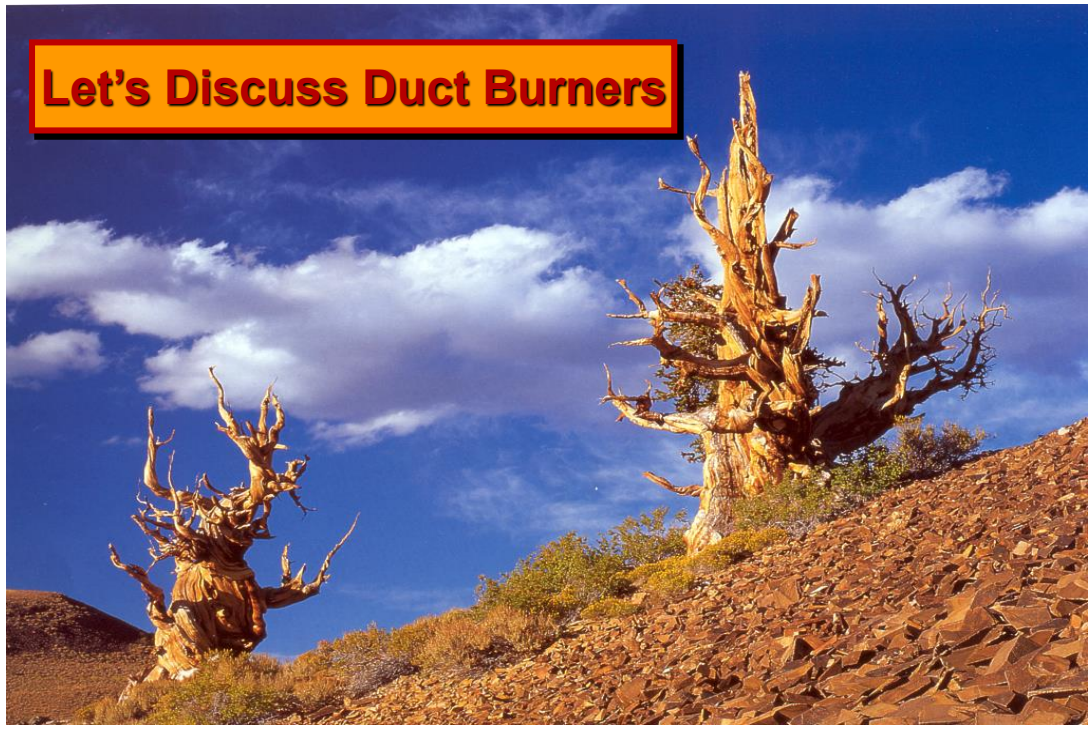

SECTIONAL VIEW
Duct Burner
Perforated Plate
Gas Flow
Outlet Stack
CO Catalyst
SCR Catalyst

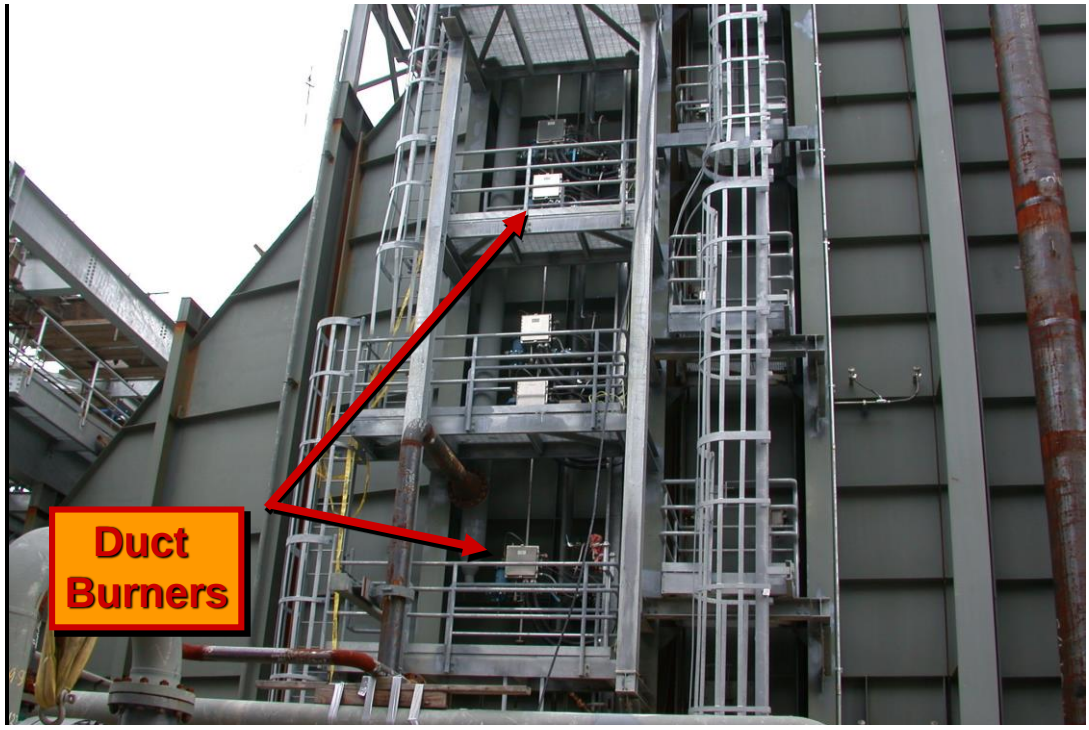

LM6000 Peaking Plant


GAS TURBINE COMBINED CYCLE
Power Plant System Schematic
ELECTRICAL SUBSTATION
UTILITY GRID
200,000 KILOWATTS
NATURAL GAS FUEL
CLEAN WATER
105°F AIR
COMPRESSOR
TURBINE
GENERATOR No. 1
75°F
STACK
200°F
COMBUSTERS
DRAIN
HIGH EFFICIENCY FILTER
GAS TURBINE GENERATOR UNIT (260,000 HORSE POWER)
EVAPORATIVE COOLING
STEAM BOILER
WATER HTR.
100,000 KILOWATTS
Combined Cycle Facility
EXHAUST GAS 1000°F
HEAT RECOVERY STEAM GENERATOR (HRSG)
1800 PSI 950°F STEAM
RAW WATER
GENERATOR No. 2
STEAM TURBINE
TURBINE EXHST 27" Hg VACUUM AT 133°F
COOLING TOWER
COOLING WATER
WATER MAKE-UP
WATER TREATMENT
COGENERATION THERMAL HOST (OPTIONAL)
BLOW DOWN WASTE WATER
150 PSI STEAM
STEAM CONDENSER
CONDENSATE
CONDENSATE
RAW WATER MAKE-UP
PROCESS STEAM
CALPINE


GAS TURBINE COMBINED CYCLE COGENERATION PROJECT
Cogeneration System Schematic
ELECTRICAL SUBSTATION
300,000 KILOWATTS
TO UTILITY GRID
CO REMOVAL CATALYST (OPTIONAL)
NOX/VOC REMOVAL CATALYST
HIGH PRESSURE STEAM DRUM
INTERMEDIATE PRESSURE STEAM DRUM
LOW PRESSURE STEAM DRUM
200°F
STACK
SILENCER OPTIONAL
AMMONIA INJECTION
EVAPORATIVE COOLING
NATURAL GAS FUEL SUPPLY
Ambient Air 105°F
75°F
COMBUSTION CHAMBERS
1200°F
200,000 Kilowatts
1000°F
STEP-UP TRANSFORMER
GENERATOR BREAKER
EXCITER
GENERATOR
COMBUSTION TURBINE
DUCT BURNER (OPTIONAL)
HEAT RECOVERY STEAM GENERATOR (HRSG)
HIGH PRESSURE STEAM 1,800 PSIG/950°F
BOILER FEED PUMP
CONDENSATE RETURN
100,000 KILOWATTS
STEAM TURBINE
150 PSIG
COGENERATION THERMAL HOST
ADMISSION STEAM
PROCESS STEAM
CONDENSER
WATER TREATMENT
CATION BED
ANION BED
DEMIN WATER STORAGE TANK
HOT WELL
HEAT REMOVAL
MAKEUP WATER
WATER FORWARDING PUMP
DEMINERALIZER SYSTEM
RAW WATER MAKEUP
WASTEWATER
CONDENSATE PUMP
MAKEUP WATER
BLOWDOWN (WASTEWATER)
PROJECT THERMAL HOST SITE
CALPINE


Combined
Cycle
w/By-pass

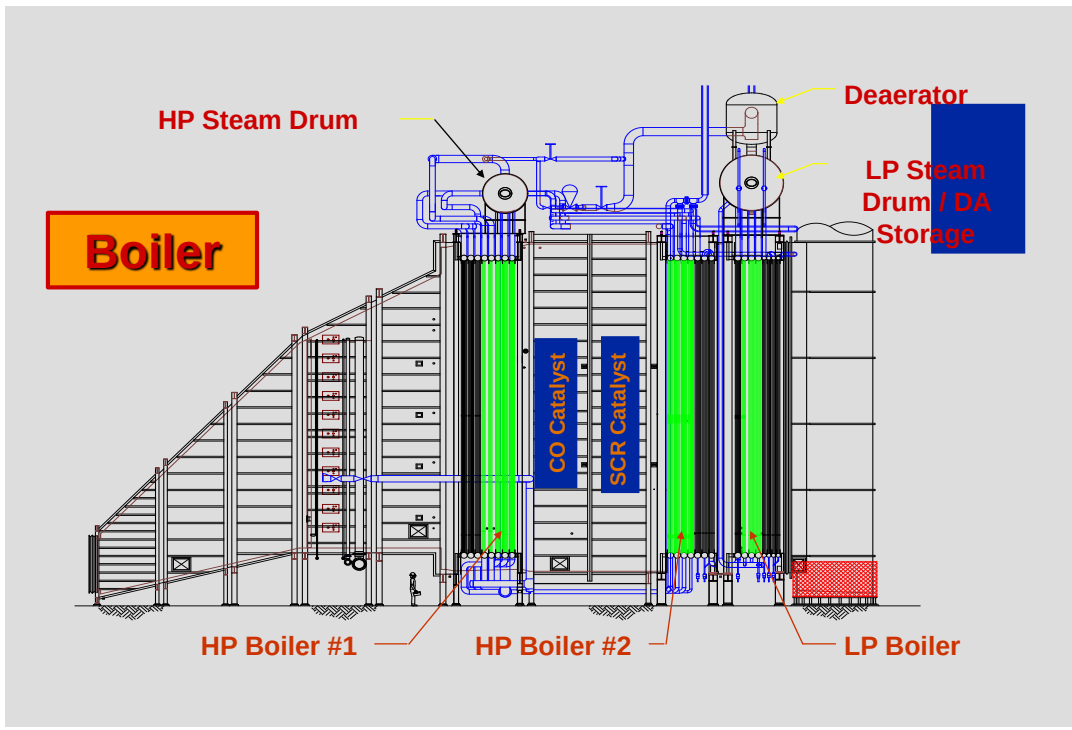

Let's Discuss Duct Burners

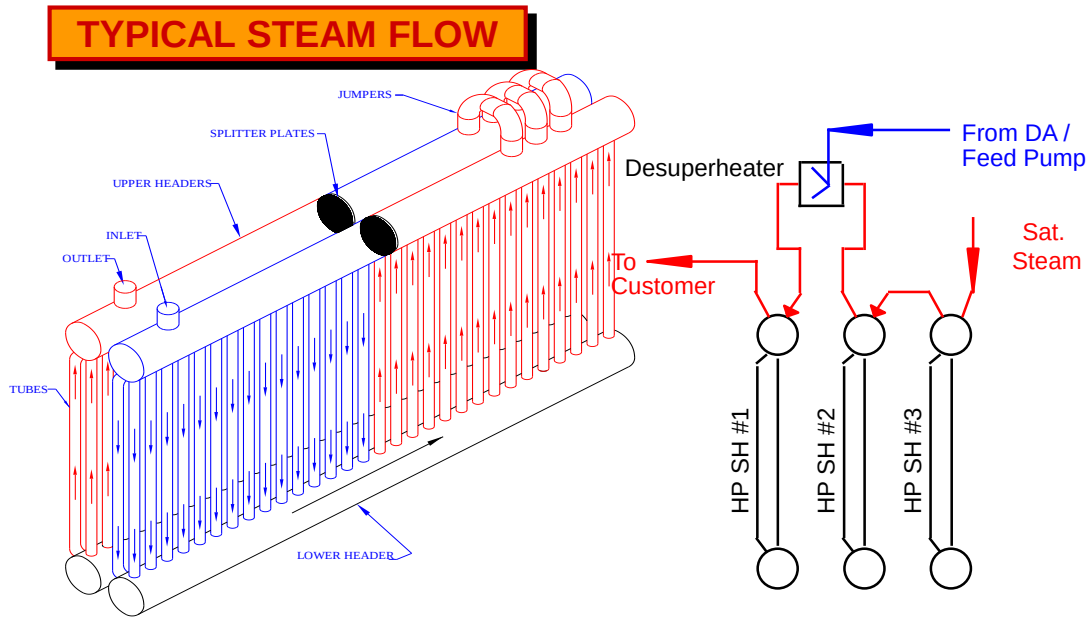

Duct
Burners


Boiler
Installation
LIEBHERR

HRSG Overview

- Superheater
  - take saturated steam from the drum and increase the temperature of the steam
- Evaporator
- Economizer

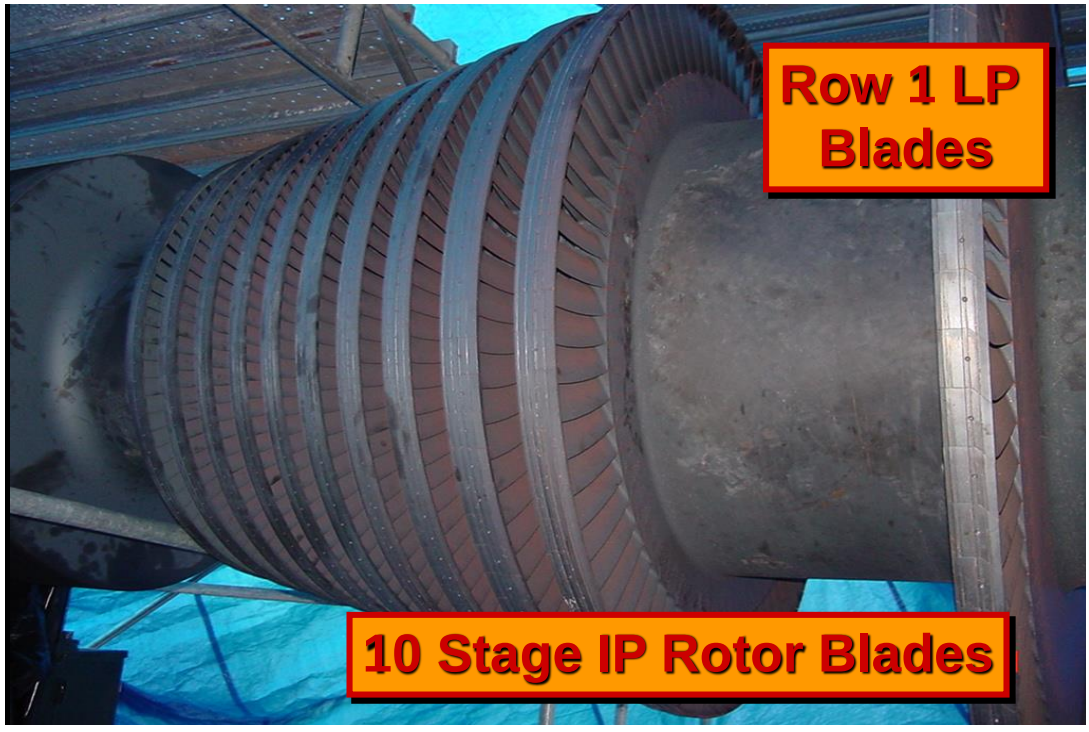



TYPICAL STEAM FLOW
JUMPERS
SPLITTER PLATES
UPPER HEADERS
INLET
OUTLET
TUBES
LOWER HEADER
Desuperheater
From DA / Feed Pump
Sat. Steam
To Customer
HP SH #1
HP SH #2
HP SH #3


Steam Lines to Steam Turbine


Steam Turbine


LP Steam Turbine


Row 1 LP Blades
10 Stage IP Rotor Blades

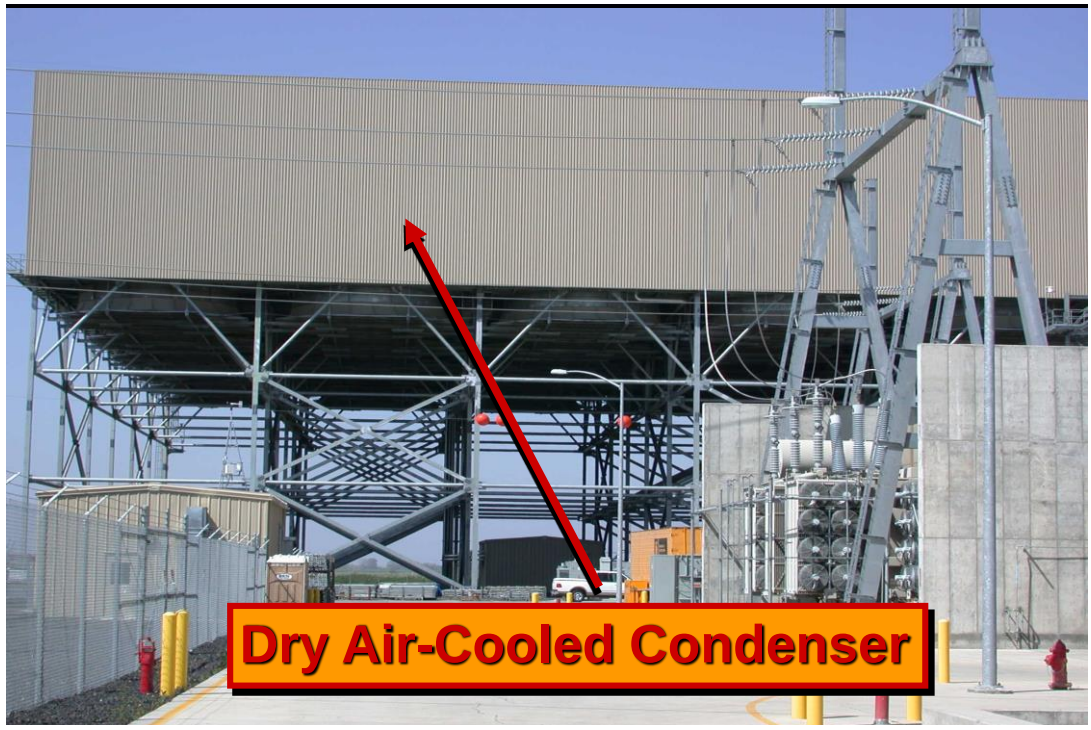

LP Steam Turbine: Row 3 & 4


Steam Turbine


Cooling Towers

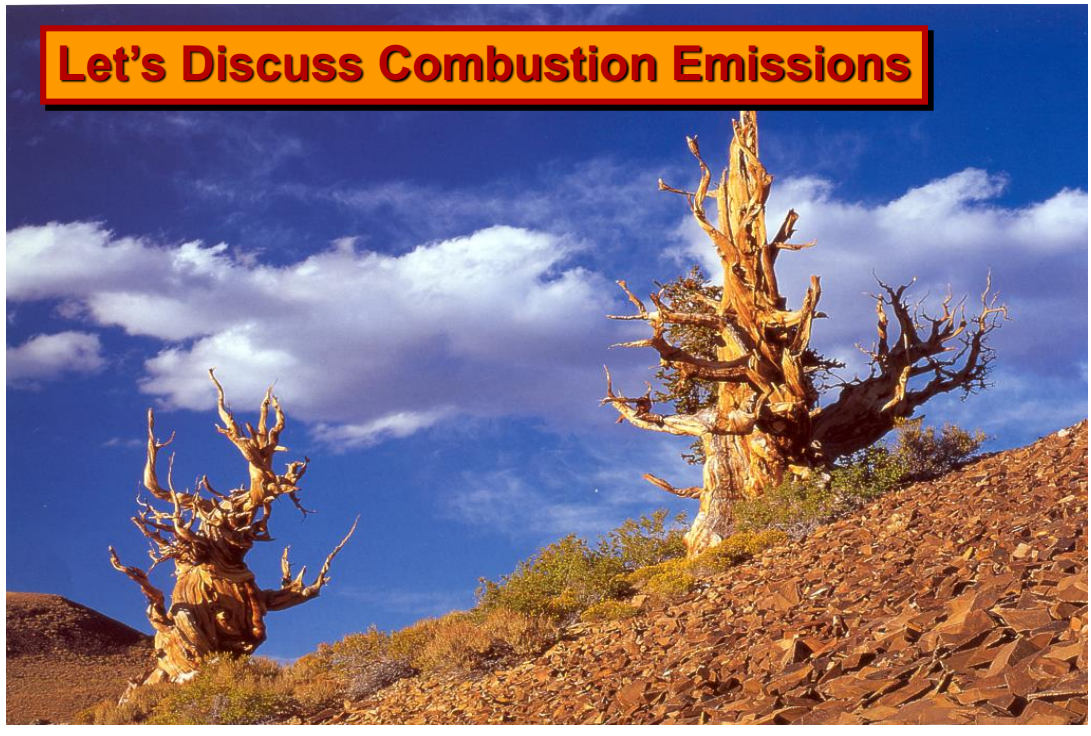

Let's Discuss Dry Air-Cooling


Steam Turbine to
Dry Air Cooling

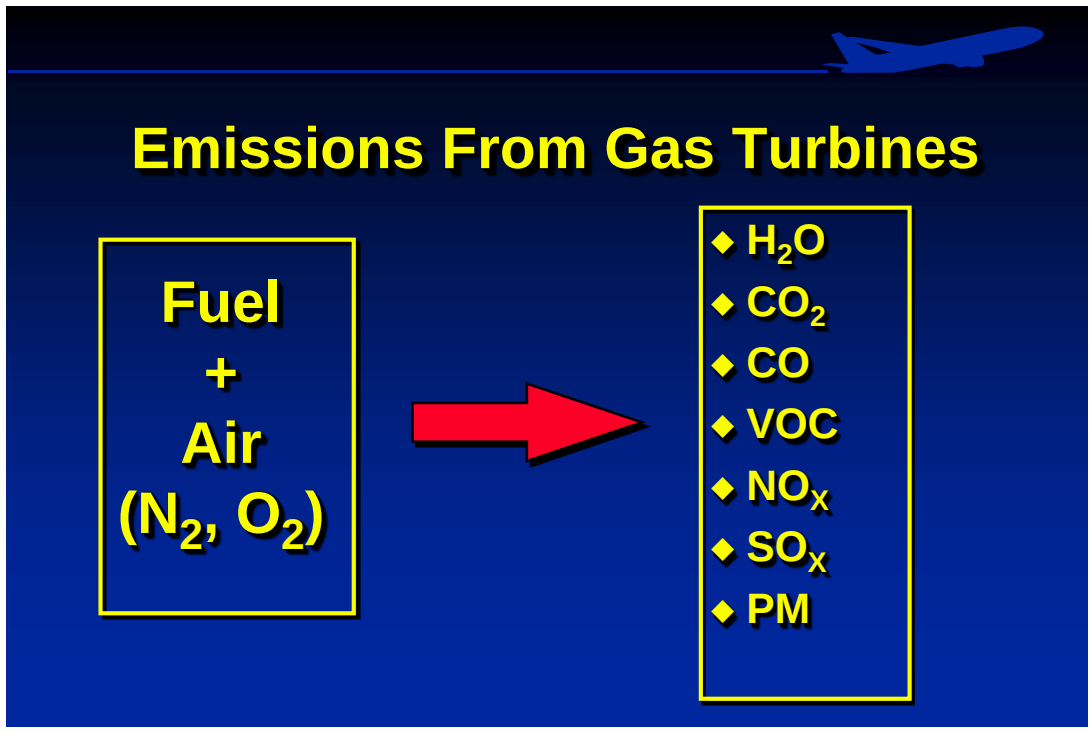

Dry Air-Cooled Condenser

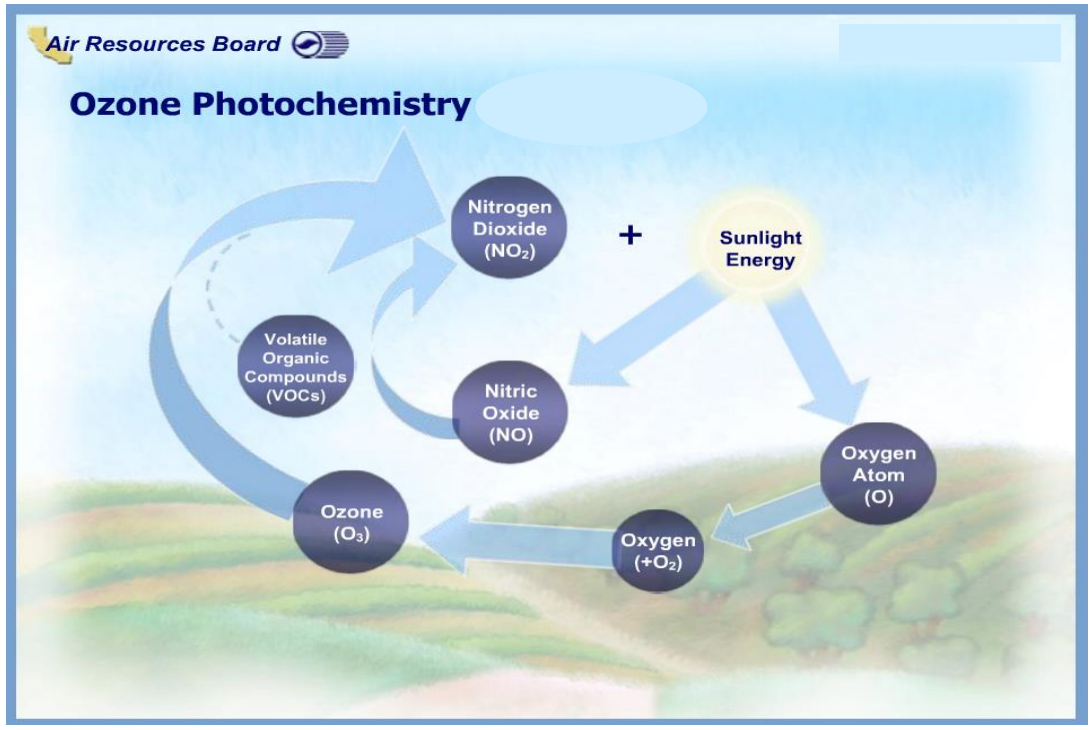

Dry Air-Cooled Condenser Fans


Dry Air-Cooled Condenser Fans


Let's Discuss Combustion Emissions


Prometheus Tree – 4,844 years old

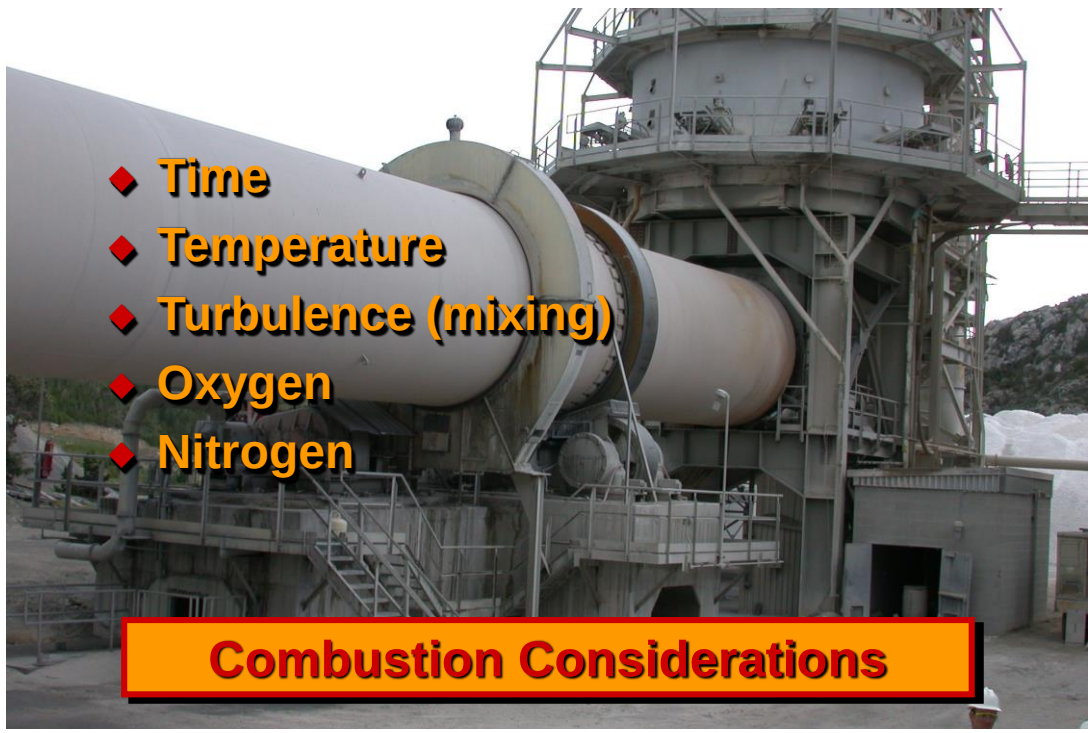

Emissions From Gas Turbines
Fuel
+
Air
(N_2, O_2)
H_2O
CO_2
CO
VOC
NO_X
SO_X
PM

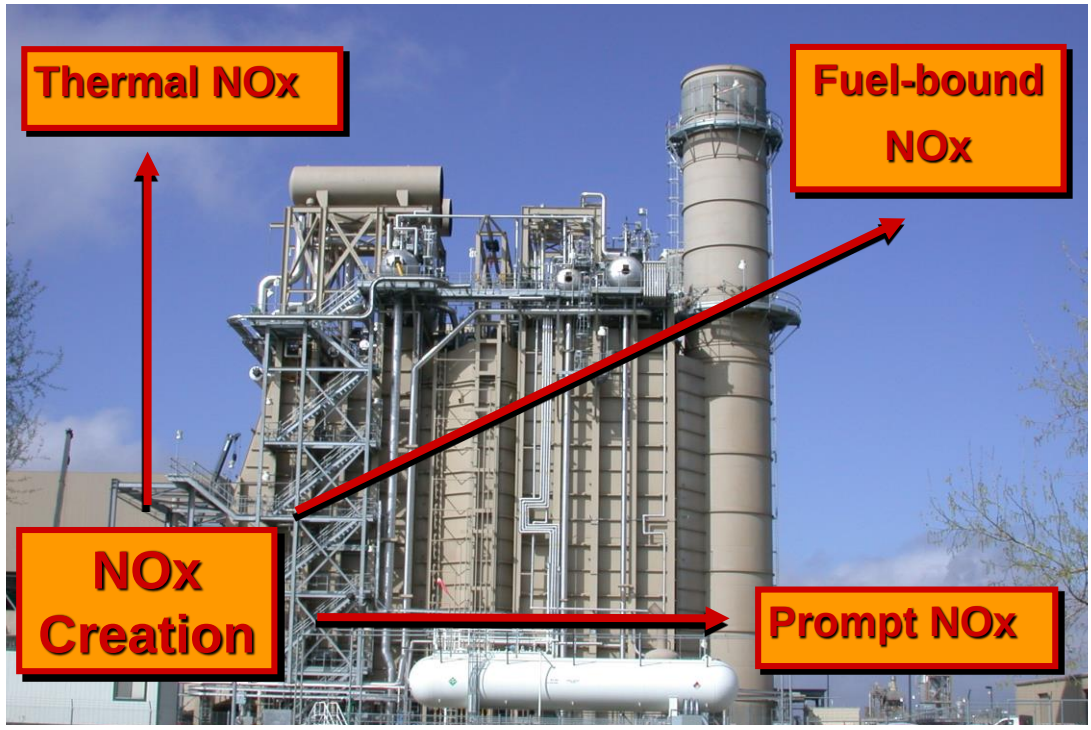

Air Resources Board
Ozone Photochemistry
Nitrogen Dioxide (NO_2)
+
Sunlight Energy
Volatile Organic Compounds (VOCs)
Nitric Oxide (NO)
Oxygen Atom (O)
Ozone (O_3)
Oxygen ($+O_2$)

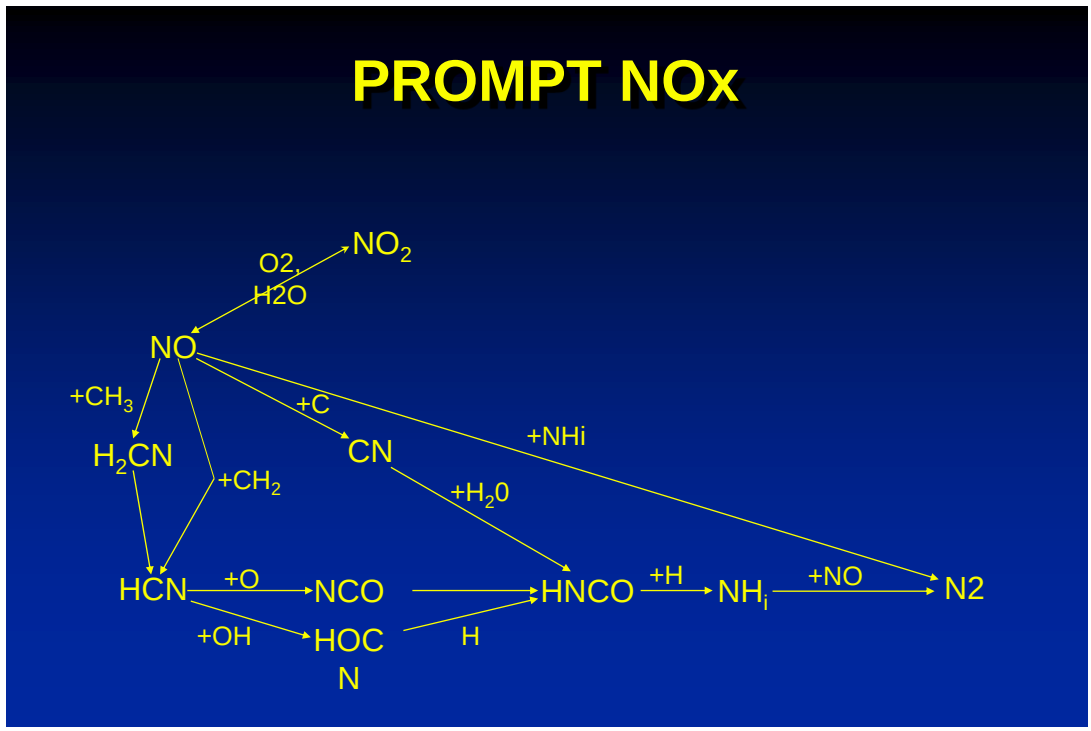

Let's Discuss Emissions Controls

Emissions Control Methods

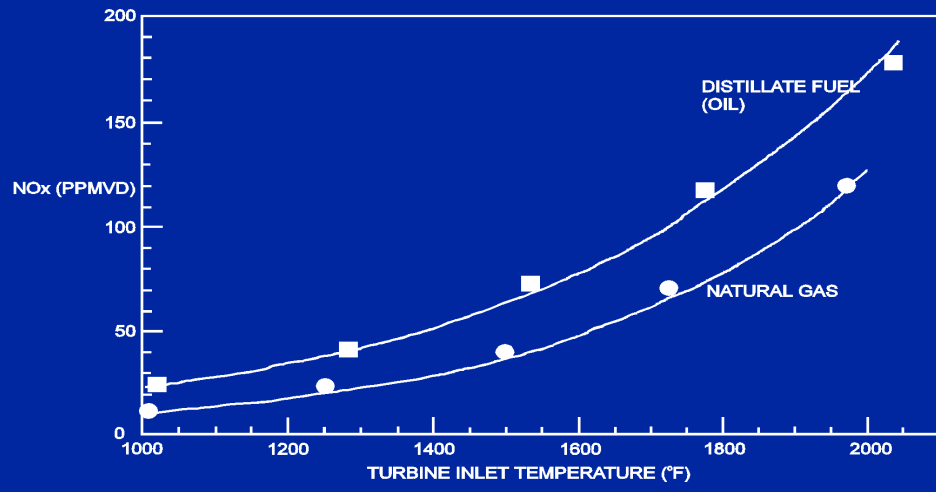
- Engine design
- Proper maintenance
- Operations
- Fuel types
- Combustion modifications
- Exhaust treatment




Thermal NOx
Fuel-bound NOx
NOx Creation
Prompt NOx


PROMPT NOx
O2, H2O
NO2
NO
+CH3
H2CN
+CH2
+C
CN
+NHi
+H20
HCN
+O
NCO
+OH
HOC N
HNCO
H
+H
NHi
+NO
N2

NOx vs. Turbine Inlet Temperature



Thermal NOx vs. Equivalence Ratio

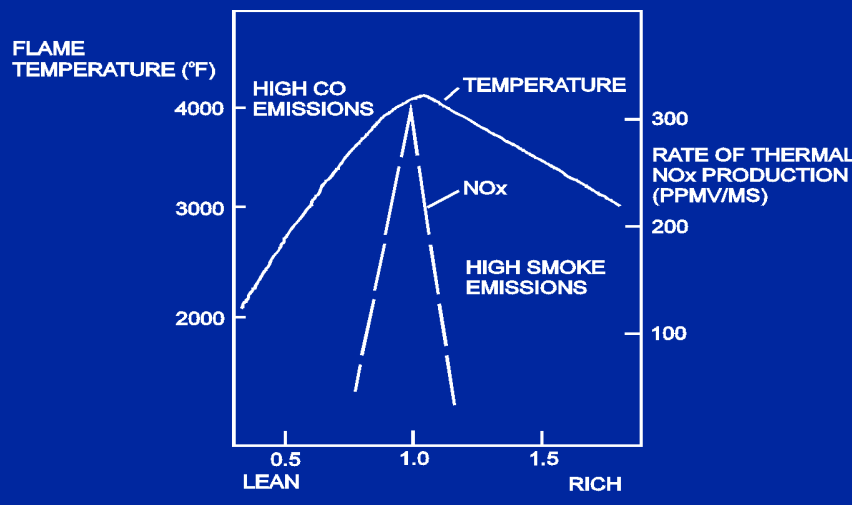
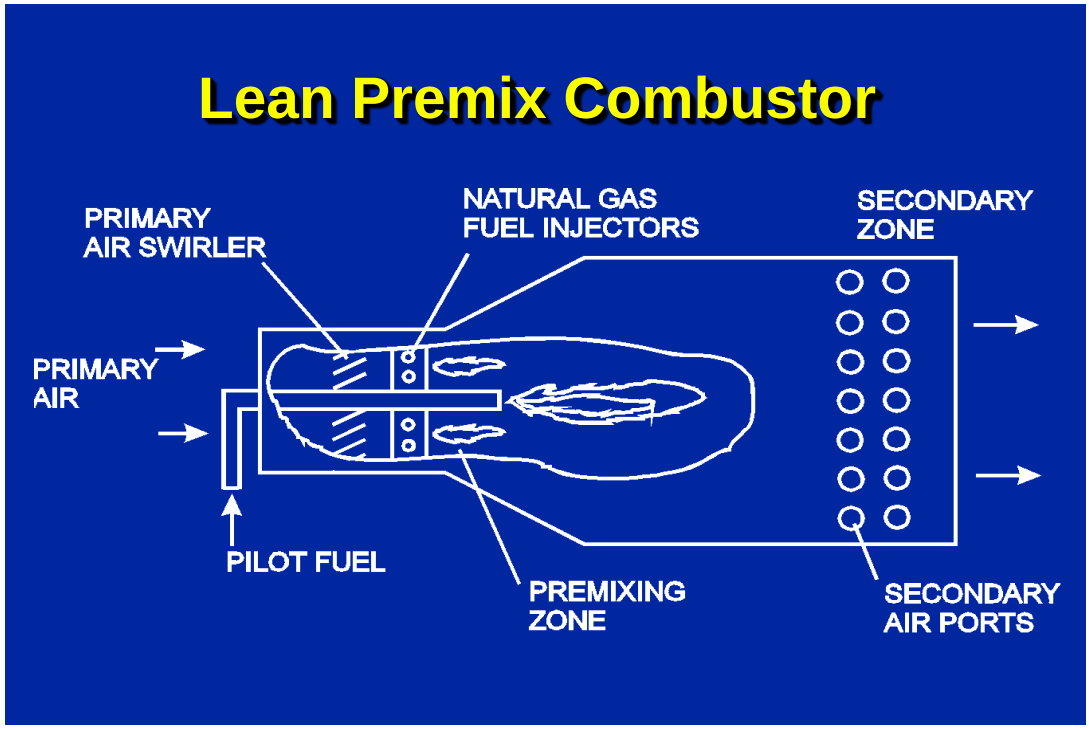
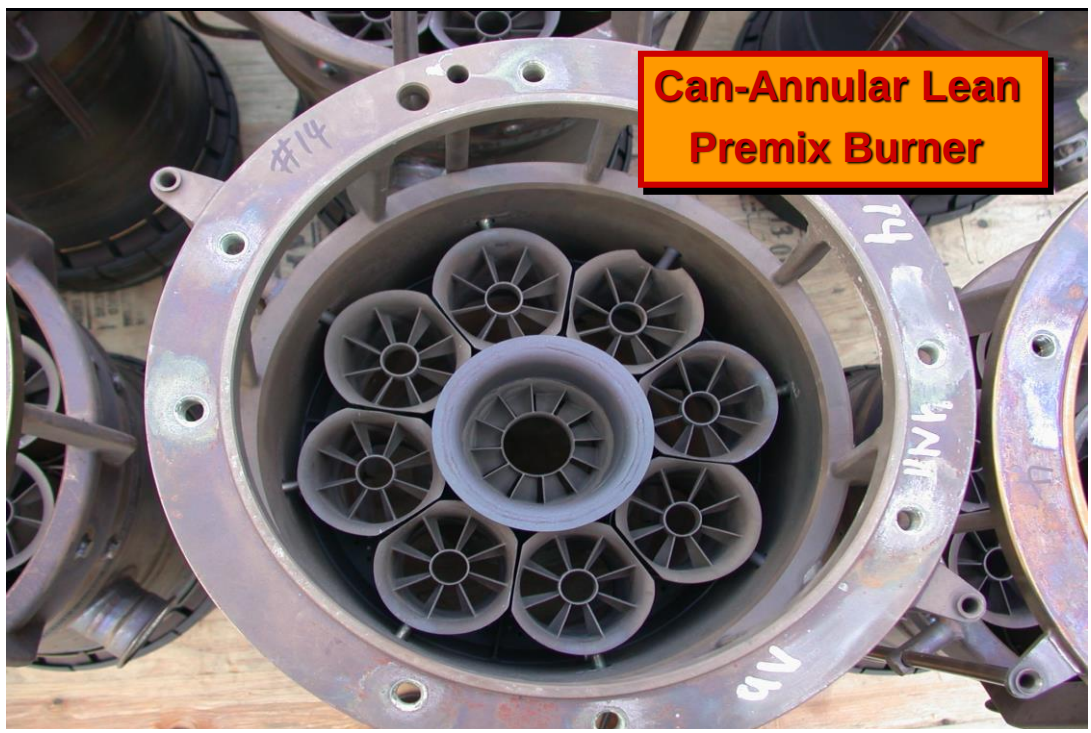
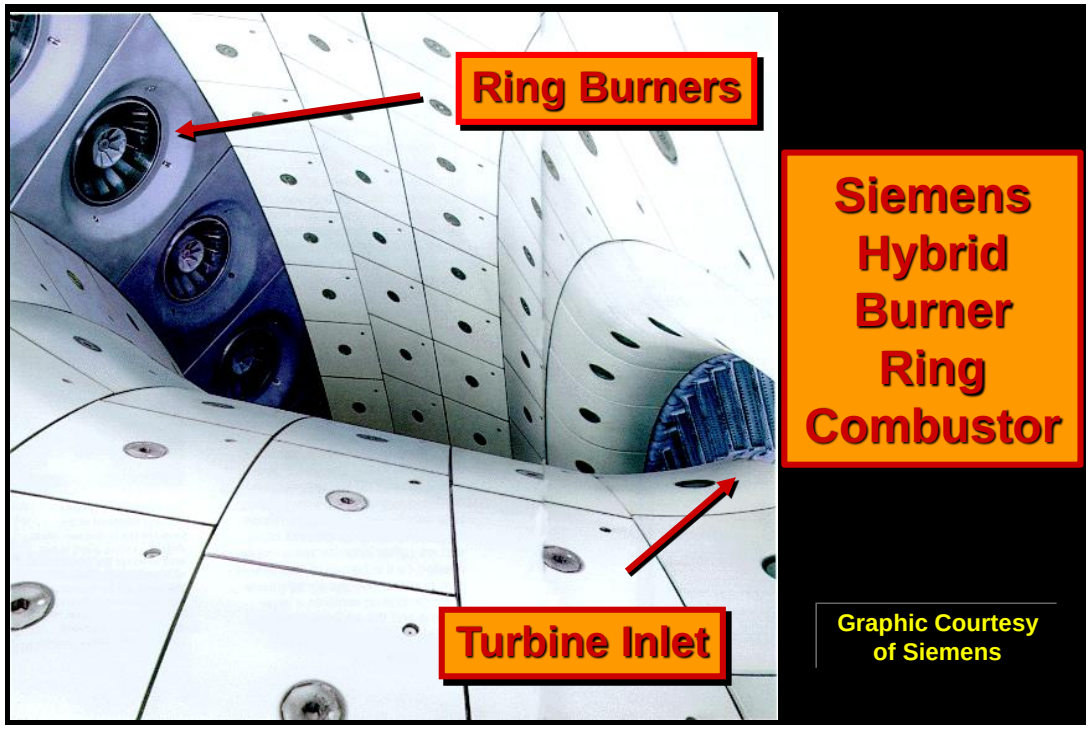


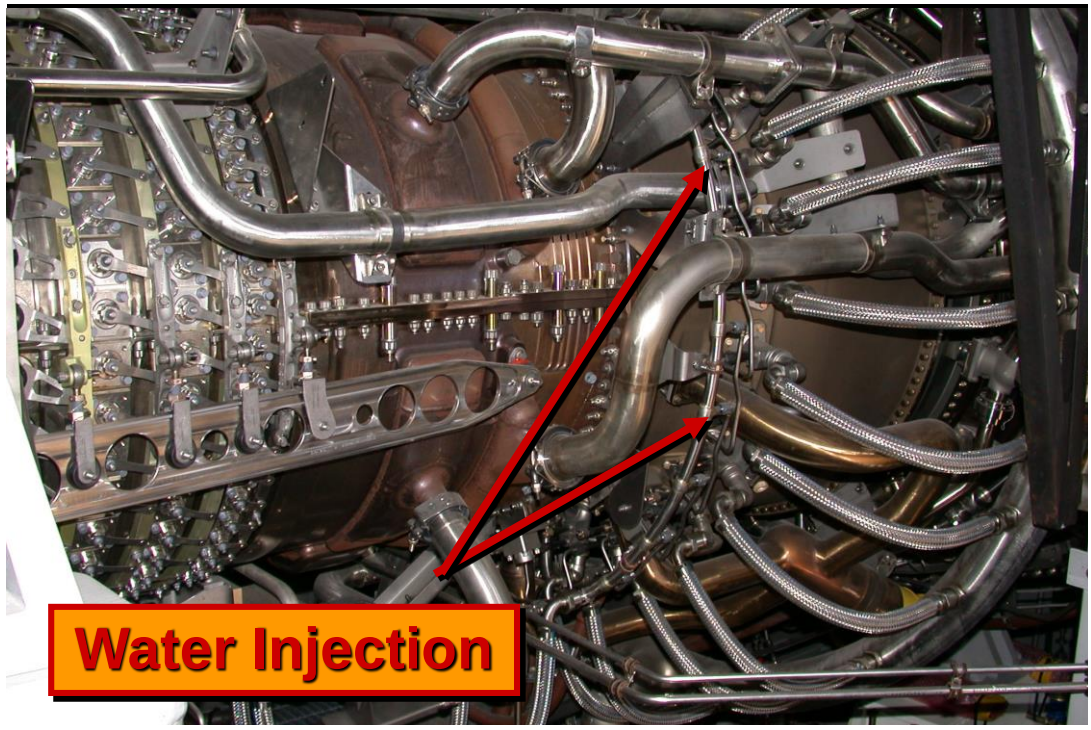
Figure 301.2


Lean Premix Combustor
PRIMARY AIR SWIRLER
NATURAL GAS FUEL INJECTORS
SECONDARY ZONE
PRIMARY AIR
PILOT FUEL
PREMIXING ZONE
SECONDARY AIR PORTS


Can-Annular Lean Premix Burner

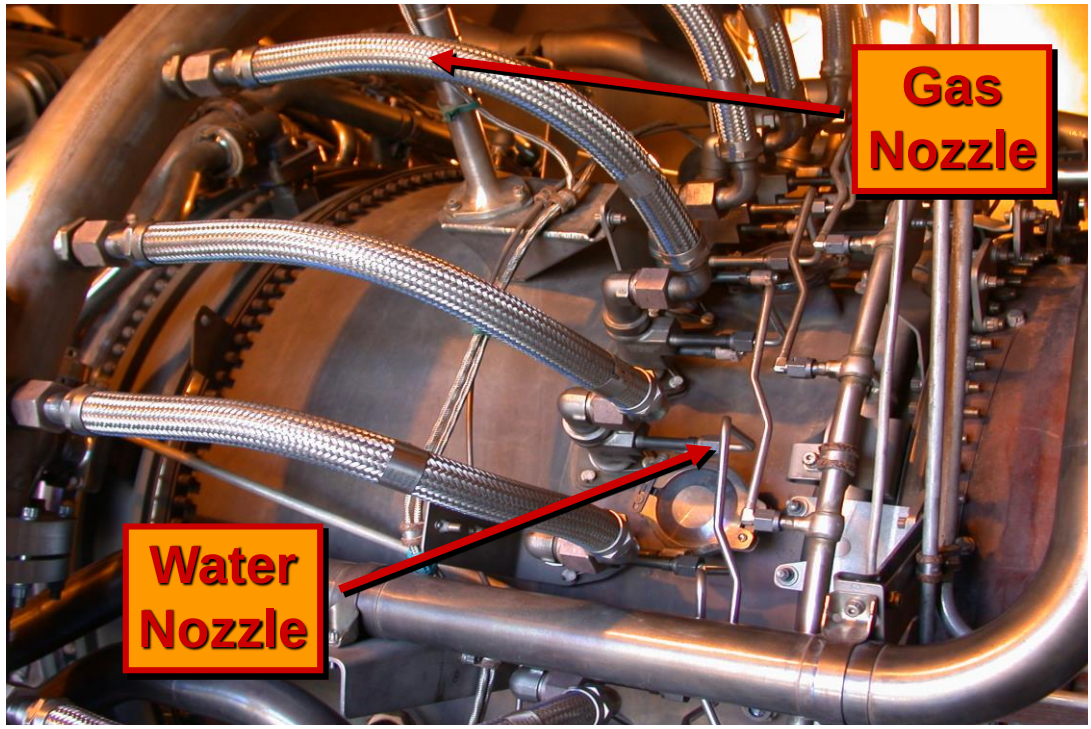

Ring Burners
Turbine Inlet
Siemens Hybrid Burner Ring Combustor
Graphic Courtesy of Siemens


Let's Discuss Steam/Water Injection



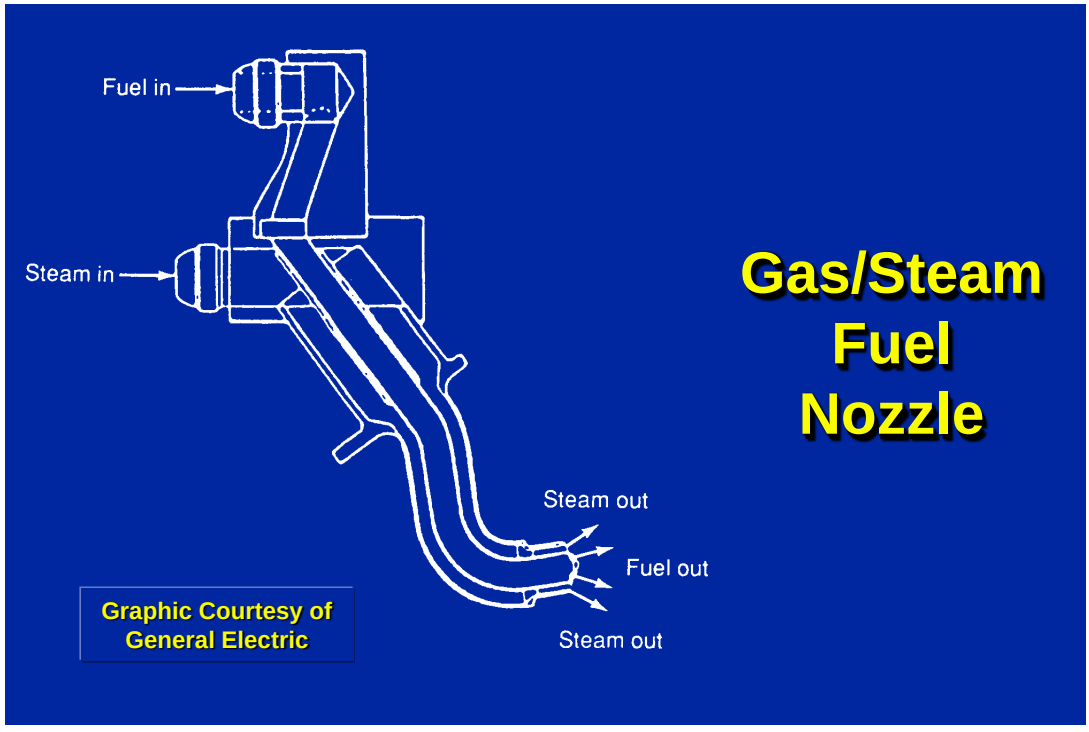
Water & Steam Injection NOx Control

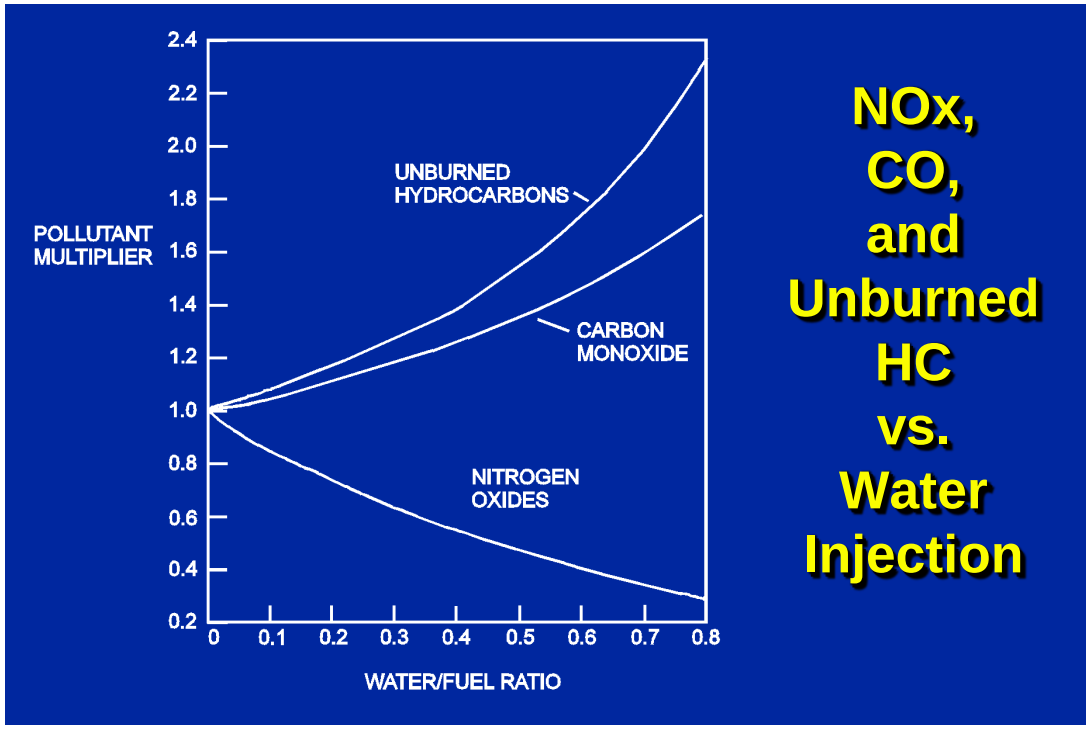
- Advantages
  - Reduces NOx
  - Increases power output
- Disadvantages
  - Water treatment expense
  - Increased fuel use
  - Increases HC
  - Increases CO
  - Increased wear & maintenance

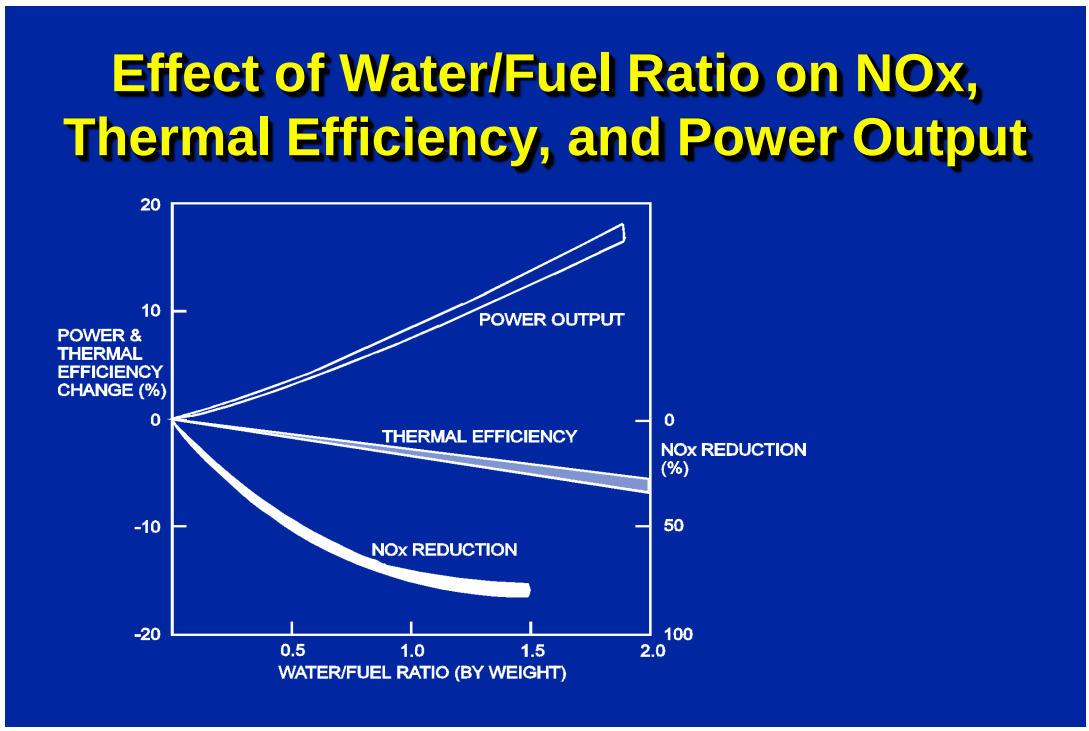

Gas
Nozzle
Water
Nozzle

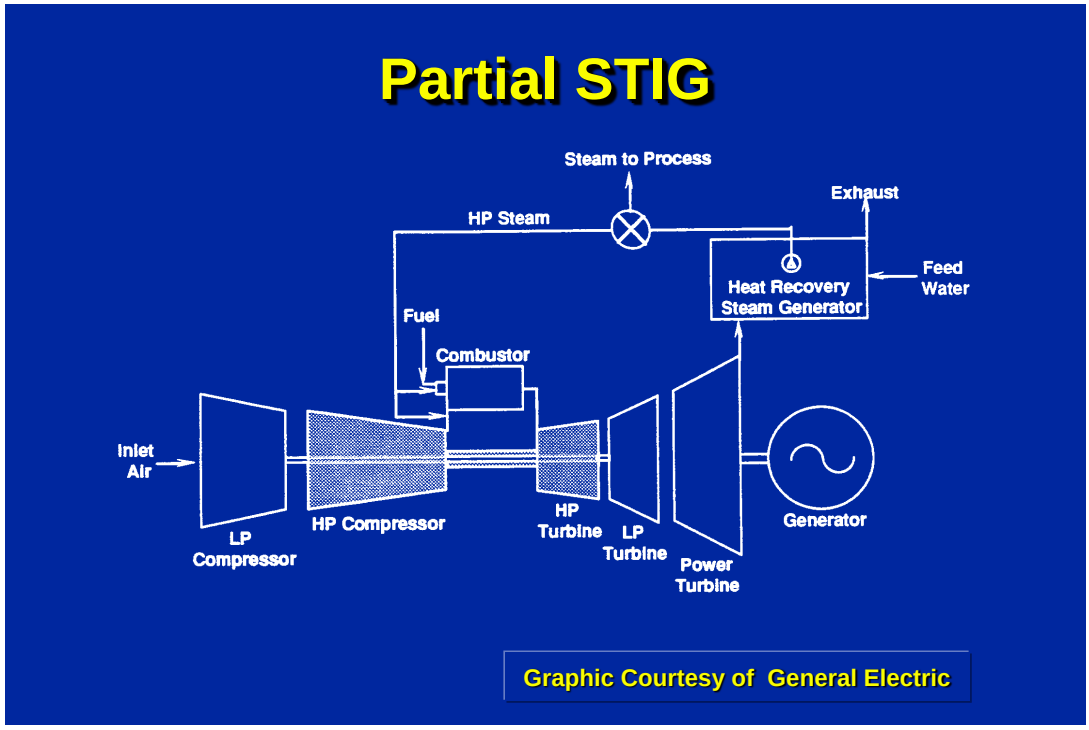

Water Treatment

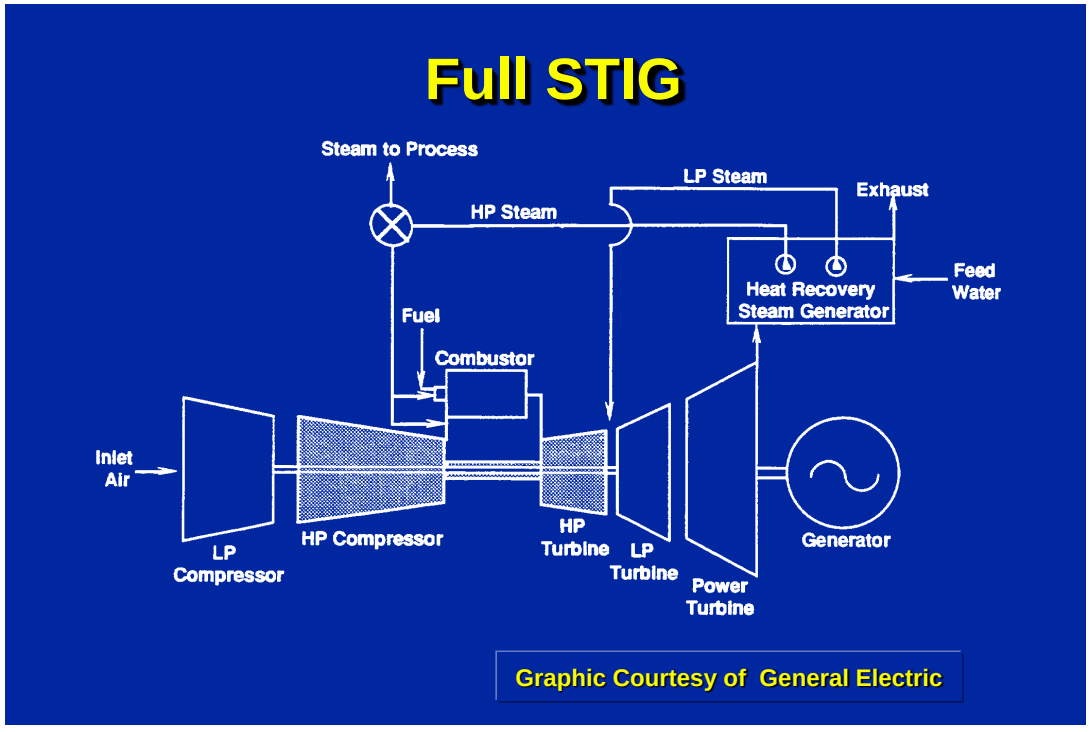

Water Treatment
De-Min. Process

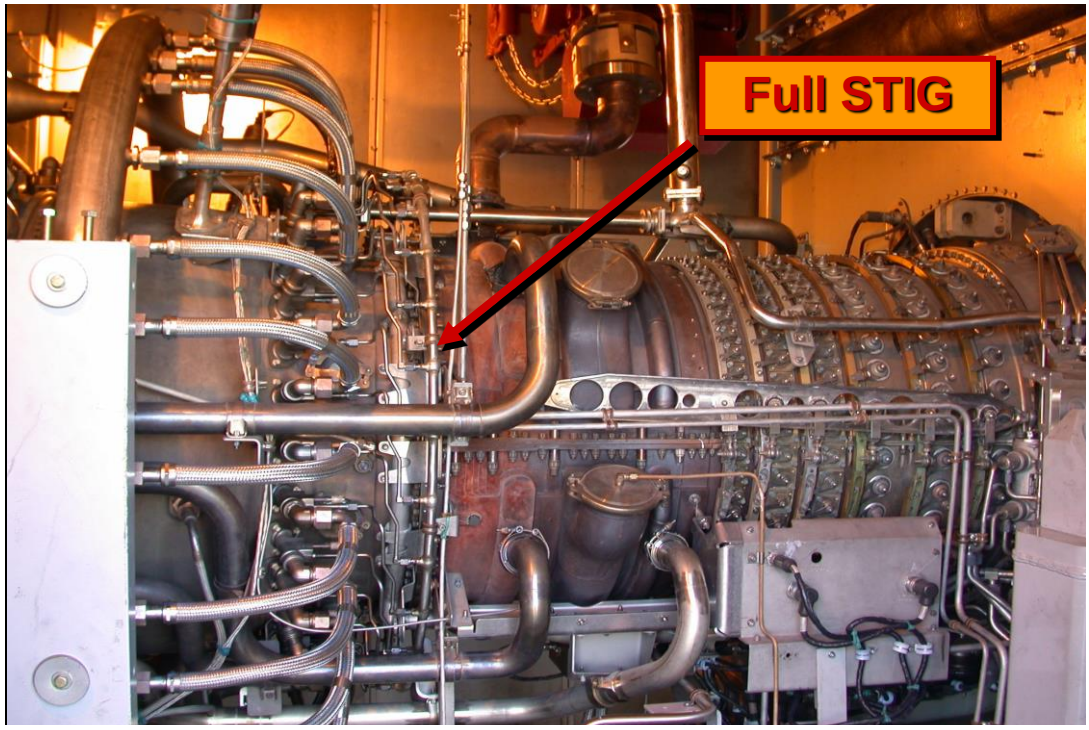

Fuel in
Steam in
Steam out
Fuel out
Steam out
Graphic Courtesy of
General Electric
Gas/Steam
Fuel
Nozzle


2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
POLLUTANT MULTIPLIER
UNBURNED HYDROCARBONS
CARBON MONOXIDE
NITROGEN OXIDES
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
WATER/FUEL RATIO
NOx, CO, and Unburned HC vs. Water Injection


Effect of Water/Fuel Ratio on NOx, Thermal Efficiency, and Power Output
20
10
0
-10
-20
POWER & THERMAL EFFICIENCY CHANGE (%)
POWER OUTPUT
THERMAL EFFICIENCY
NOx REDUCTION
0
50
100
NOx REDUCTION (%)
0.5
1.0
1.5
2.0
WATER/FUEL RATIO (BY WEIGHT)

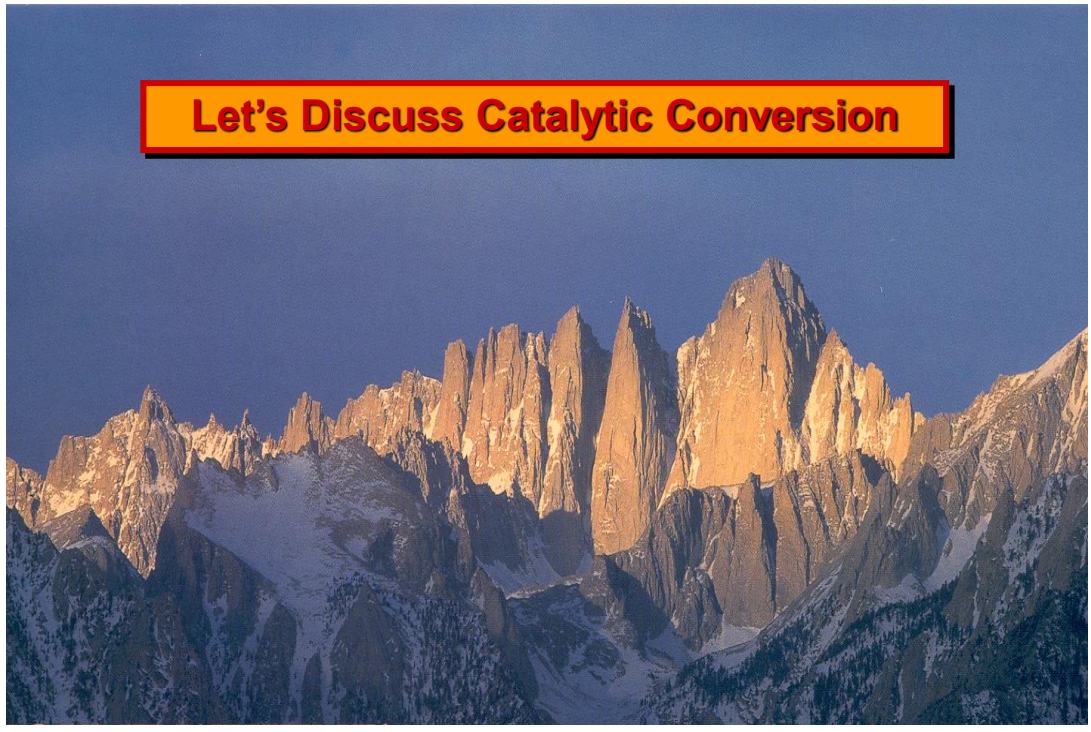

Partial STIG
Steam to Process
Exhaust
HP Steam
Heat Recovery
Steam Generator
Feed
Water
Fuel
Combustor
Inlet
Air
LP
Compressor
HP Compressor
HP
Turbine
LP
Turbine
Power
Turbine
Generator
Graphic Courtesy of General Electric


Full STIG
Steam to Process
LP Steam
Exhaust
HP Steam
Heat Recovery
Steam Generator
Feed
Water
Fuel
Combustor
Inlet
Air
LP
Compressor
HP Compressor
HP
Turbine
LP
Turbine
Power
Turbine
Generator
Graphic Courtesy of General Electric



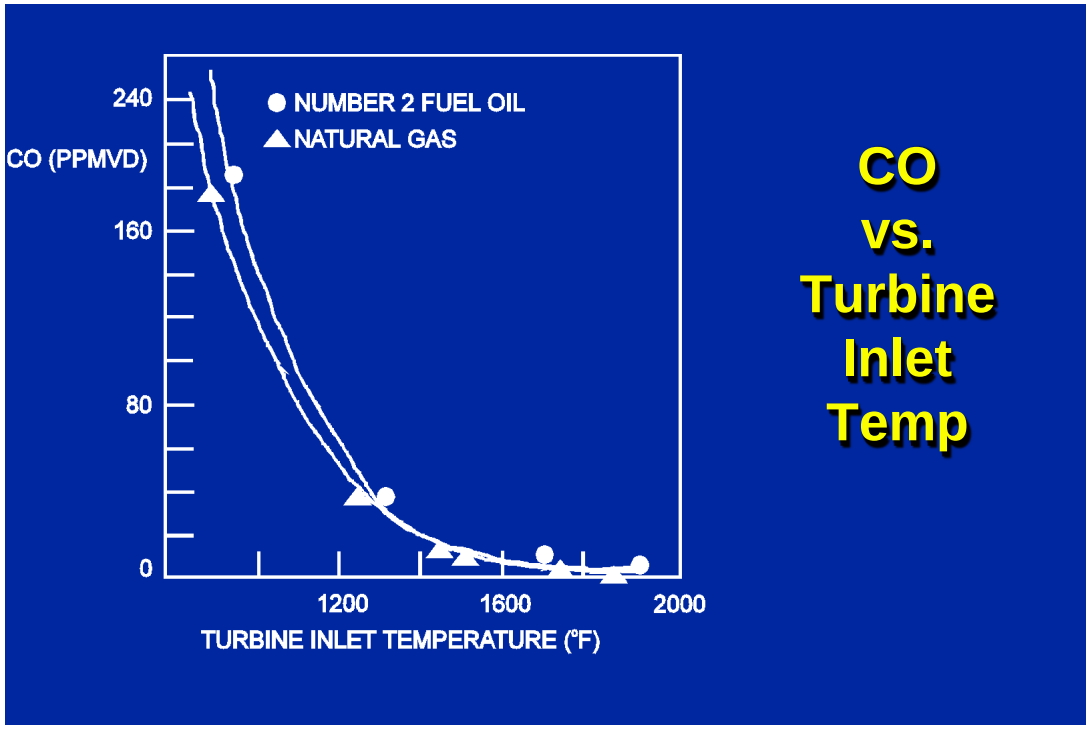
Water and Steam Injection - Summary

- NOx reduced
- Power output increased
- Thermal efficiency decreased
- Fuel flow rate increased
- Maintenance frequency increased



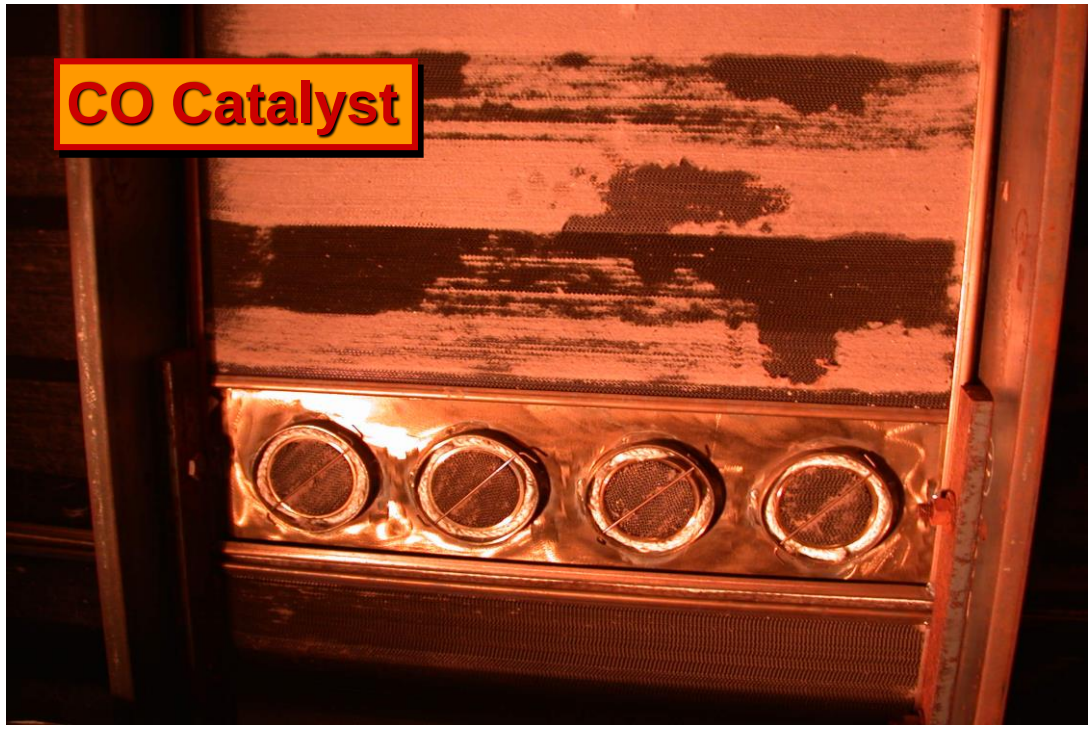
Catalytic Conversion

- CO is oxidized → CO_2 Oxidation catalyst
- NOx is reduced → N_2 Reduction catalyst



CO Catalyst

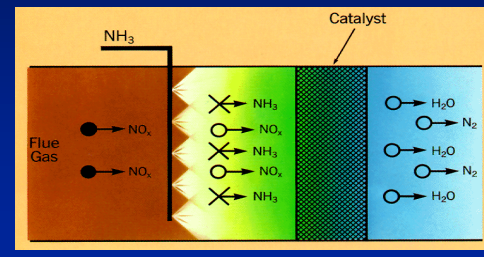
- $2CO + O_2 \rightarrow 2CO_2$
- 700 to 1000 °F operating temp
- 90% efficient
- Pressure drop 1-2 in. H_2O
- Problems
  - Expensive
  - High maintenance
  - Catalyst replacement & disposal


CO Catalyst


Let's Discuss Selective Catalytic Reduction (SCR)

Selective Catalytic Reduction (SCR)

- NOx control thru ammonia (NH_3) injection
- $4NO + 4NH_3 + O_2 \rightarrow 4N_2 + 6H_2O$
- $2NO_2 + 4NH_3 + O_2 \rightarrow 3N_2 + 6H_2O$
- 90-95% control
- Problems
  - Expensive
  - High maintenance
  - Ammonia "slip"
  - Catalyst replacement & disposal




AMMONIA
AMMONIA
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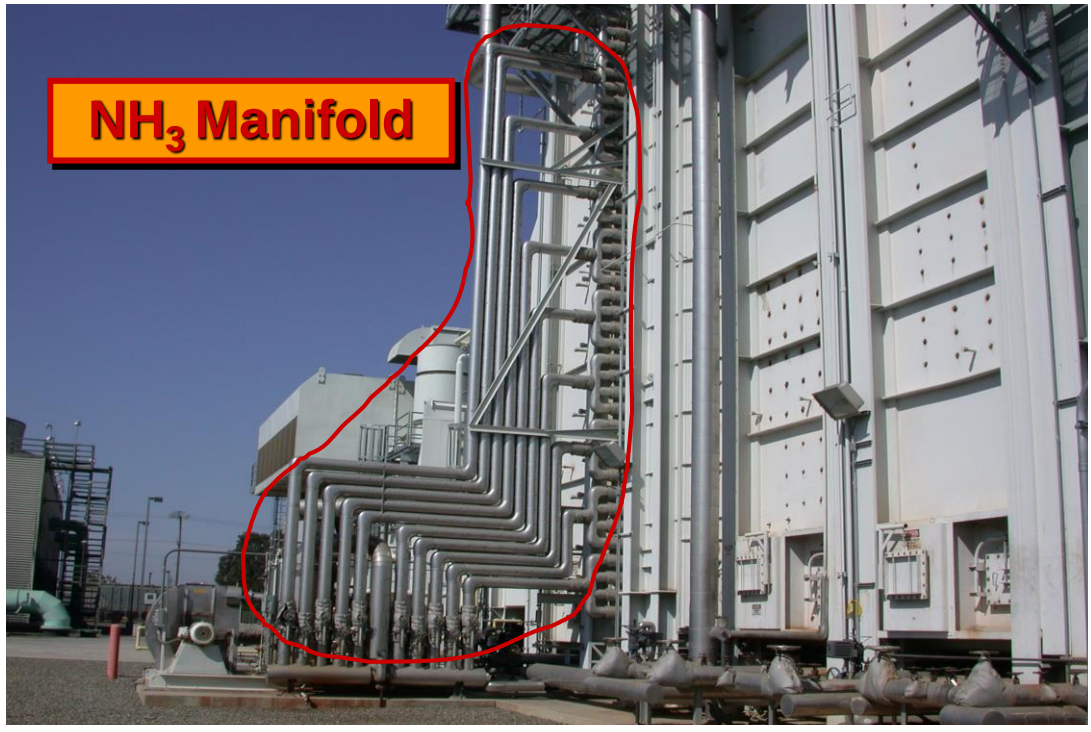
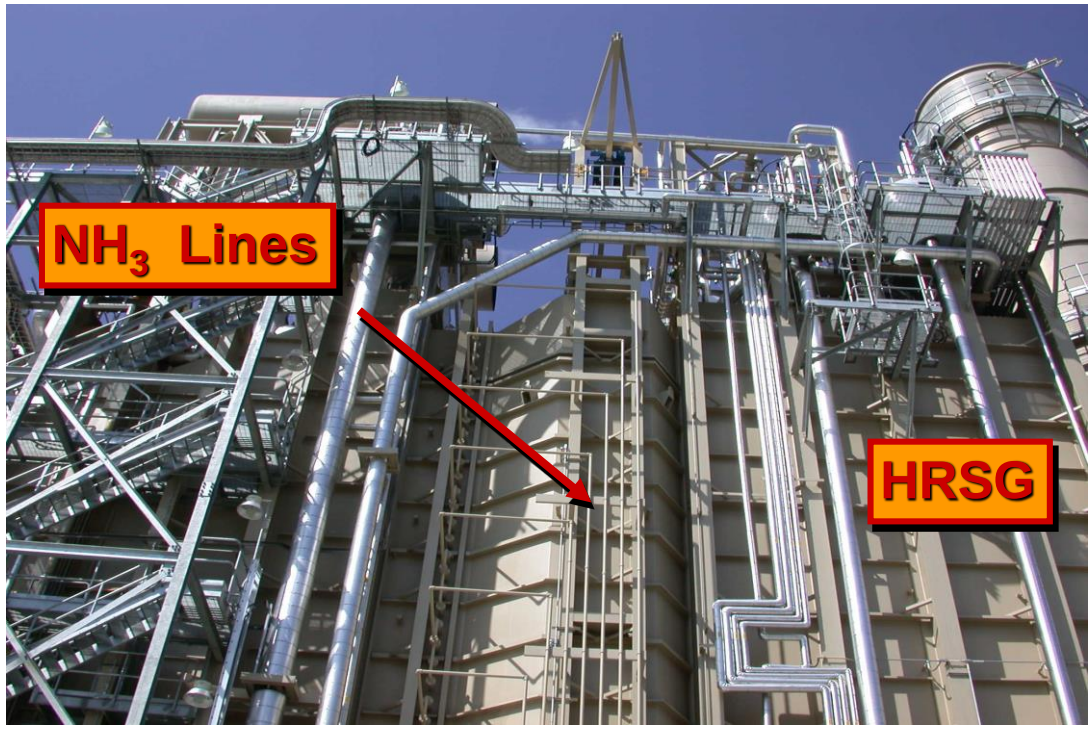
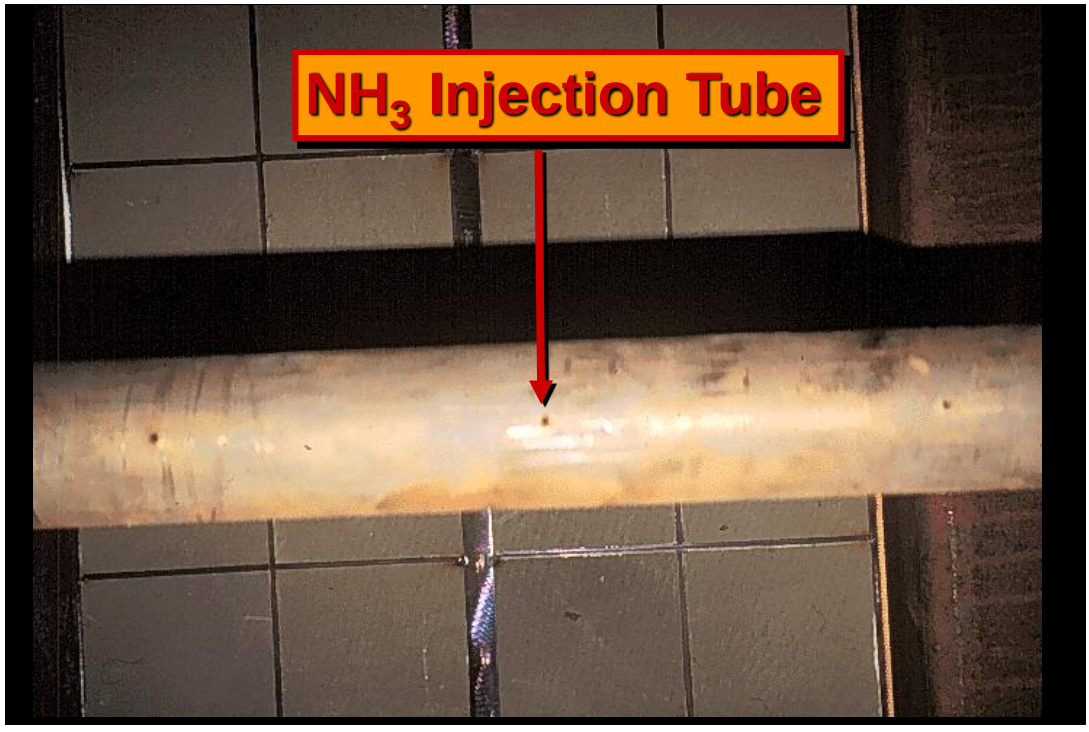
NH_3 Lines

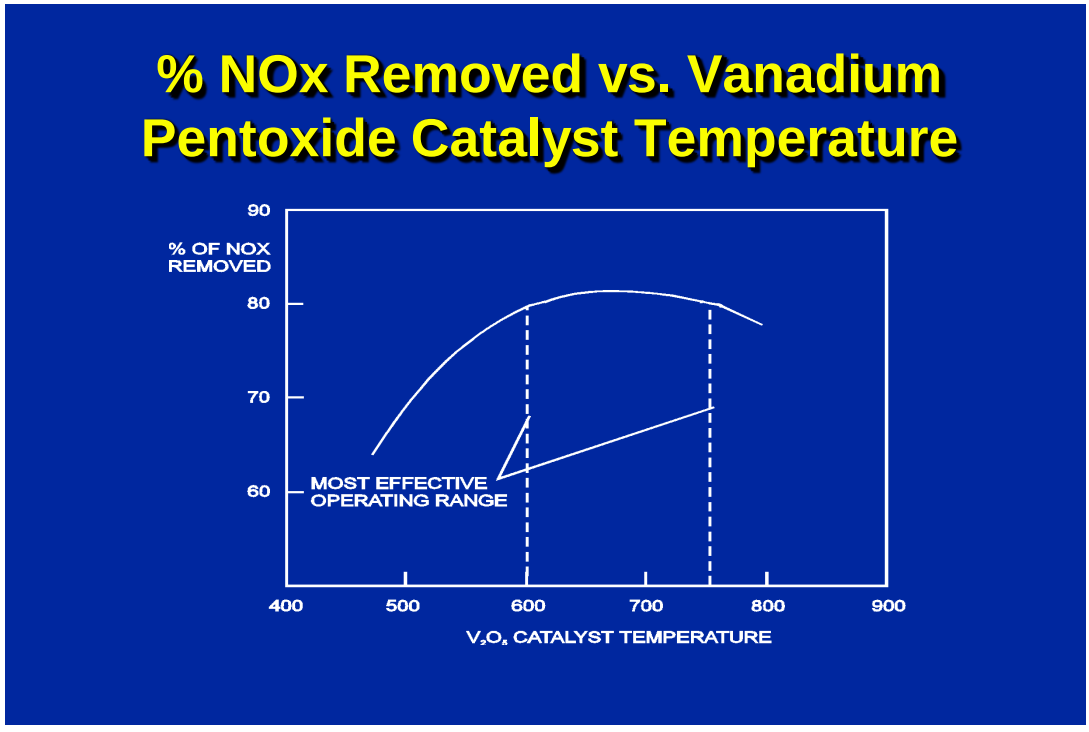

NH_3 Manifold


NH_3 Lines
HRSG


NH_3 Injection Tube

Catalyst System Installation


SCR Catalyst


% NOx Removed vs. Vanadium Pentoxide Catalyst Temperature
90
% OF NOX REMOVED
80
70
60
MOST EFFECTIVE OPERATING RANGE
400
500
600
700
800
900
V2O5 CATALYST TEMPERATURE

Regulatory Requirements

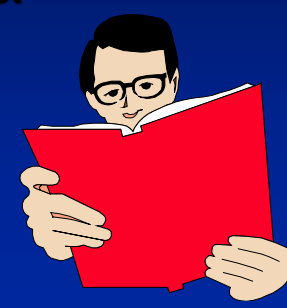
- Federal, state, and local requirements
- Turbine specific limits
- Permit requirements
- Monitoring requirements
- Visible emission limits
- Nuisance regulations
- Breakdowns & variances

Turbine Regulations

- 40 CFR Part 87 -- Control of Air Pollution From Aircraft and Aircraft Engines
- 40 CFR Part 60 Subparts GG & KKKK -- Standards of Performance for Stationary Gas Turbines (NSPS)
- Acid Rain Provisions (Parts 72, 73, 74, 75, 76, 77, & 78)
- Stationary Combustion Turbines NESHAP -- YYYY
- State Regulations, including VE
- SIP Requirements
- Local Regulations

Gas Turbine Exemptions

- Emergency use
- Military and military training
- Firefighting and flood control
- Research and development
- Certain geographical areas
- Low output
- Minimal usage



EPA Stationary Gas Turbine Limits

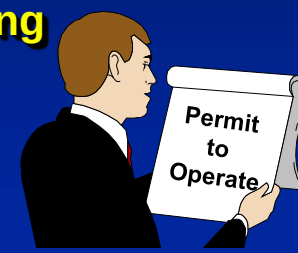
NSPS	NO_x	Sulfur in Fuel	SO_2
Subpart GG (1979-2005)	Small – (150 x 14.4/Y) + F ppm_{vd} @15%O2 Large – (75 x 14.4/Y) + F ppm_{vd} @15%O2	0.8% by weight	150 ppm_{vd} @15%O2
Subpart KKKK (2005+)	15 to 150 ppm_{vd} @15%O2 depending on size, fuel and location	26 ng SO_2/J heat input	110 ng/J gross output (65 ng/J input for biogas)
NESHAP		Formaldehyde	
Subpart YYYY		91 ppb_{vd} @15%O2	

BACT Summary for Stationary Gas Turbines

	NO_x	CO	VOC	PM_{10}	SO_x
Simple-Cycle	2.0 ppmvd @ 15%O2	6 ppmvd	2 ppmvd OR 0.0027 lbs/MMBtu (HHV)	Equiv. to natural gas with fuel sulfur < 1 grain/100 scf	Equiv to natural gas with fuel sulfur < 1 grain/100 scf (< 0.55 ppmvd)
Combined-Cycle & Cogen	2.0 ppmvd @ 15% O2	3.0 ppmvd	2 ppmvd OR 0.0027 lbs/MMBtu (HHV)	Equiv. to natural gas with fuel sulfur < 1 grain/100 scf	Equiv to natural gas with fuel sulfur < 1 grain/100 scf (< 0.55 ppmvd)

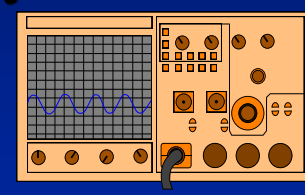
Typical Permit Conditions

- Fuel
- Hours of operation
- Water/steam and NH3 injection rates
- Emissions limits
- Continuous Emission Monitoring (CEM) requirements
- Source testing requirements
- Logs



Monitoring Requirements

- Fuel consumption
- Water/fuel ratio
- Sulfur and nitrogen content of fuel
- State/local rules may include CEMs for:
  - NOx
  - SOx
  - CO
  - O_2
  - CEMs should meet 40CFR60 App. B & F specs



Reasons for Inspections

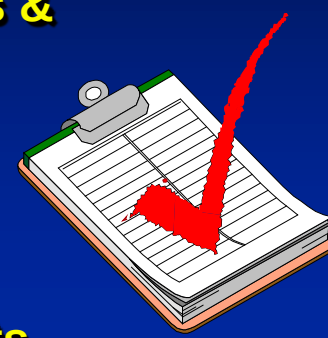
- Compliance determination
- Complaint investigation
- Source plan approval
- Review or renewal of permits
- Special studies

Pre-Inspection

- Prepare inspection report form
- File review
- Regulation review
- Equipment check
- Pre-entry & entry
- Pre-inspection meeting
- Permit check

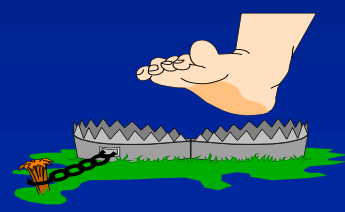
Inspection

- Visible emission evaluation
- General upkeep & maintenance
- Monitoring instruments & records
- Fuel type and quality
- Maintenance records
- Operational records
- Source tests/RATA tests



Inspector Safety

- Proper equipment
- Plant warnings
- Heat
- High pressure steam
- Electrical hazards
- Noise
- Moving parts
- Inhalation hazards
- Hazardous materials
- Turbine disintegration



Additional Information

- Turbine MACT Fact Sheet
  - https://www.epa.gov/sites/production/files/2016-03/documents/stationary_combustion_turbines_factsheet_2003.pdf

- Turbine MACT (NESHAPS for Stationary Combustion Turbines) March 5, 2004
  - https://www.govinfo.gov/content/pkg/FR-2004-03-05/pdf/04-4530.pdf

- Amendment to Turbine MACT (Exempts certain equipment) August 18, 2004
  - https://www.govinfo.gov/content/pkg/FR-2004-08-18/pdf/04-15529.pdf

- New Amendment to Turbine MACT (SSM applicability and electronic reporting)
  - https://www.epa.gov/sites/production/files/2020-01/documents/frn_combustion_turbines_rtr_final_rule.pdf

- NSPS for Stationary Combustion Turbines
  - https://www.govinfo.gov/content/pkg/FR-2006-07-06/pdf/06-5945.pdf